Technology and Language

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Hermeneutic Dimensions

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Editorial introduction

Hermeneutic Dimensions of Science and Technology

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Abstract

The editorial discusses perspectives for a hermeneutics of science and technology. It begins by appreciating the original antagonism between hermeneutics and science, between hermeneutics and technology. While the former signifies the struggle to establish the purity, transparency, and objectivity of science, the latter concerns the symbolic dimension of technology as well as practices of sense-making in human interactions with technology. And while the antagonism of hermeneutics and science persists, the latter can be solved by treating technical works on a par with artworks. If there is a hermeneutic of science and not just a hermeneutic historiography or philosophical reconstruction of science, it can be found in the technical process of modeling as a mutual attunement of theory and reality by way of the model as mediator or hermeneutic device. This conclusion for the hermeneutics of science leads on to conceptions of a hermeneutics of technical works, including models as material compositions that establish what can be done in the fields of theory and practice. – From among the twelve papers in this special issue, a first group of papers struggles with and against the „original antagonism" of science, while the second group offers perspectives for a hermeneutics of technical works.

Keywords: Hermeneutics of science; Hermeneutics of technology; Georg Christoph Lichtenberg; Heinrich Hertz; Determinacy of meaning; Works and worlds; Prospective models

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Герменевтические измерения науки и техники

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Аннотация

В редакционной статье обсуждаются перспективы герменевтики науки и техники. Она начинается с оценки изначального антагонизма между герменевтикой и наукой, между герменевтикой и техникой. В то время как первая часть означает борьбу за установление чистоты, прозрачности и объективности науки, вторая касается символического измерения техники, а также практик смыслообразования во взаимодействии человека с техникой. И хотя антагонизм герменевтики и науки сохраняется, последний может быть разрешен путем рассмотрения технических работ наравне с произведениями искусства. Если существует герменевтика науки, а не просто герменевтическая историография или философская реконструкция науки, ее можно найти в техническом процессе моделирования как взаимной настройки теории и реальности посредством модели как посредника или герменевтического устройства. Этот вывод для герменевтики науки приводит к концепциям герменевтики технических работ, включая модели как материальные композиции, которые устанавливают, что можно сделать в областях теории и практики. – Из двенадцати статей этого специального выпуска первая группа статей борется с “изначальным антагонизмом” науки и против него, в то время как вторая группа предлагает перспективы герменевтики технических работ.

Ключевые слова: Герменевтика науки; Герменевтика техники; Георг Кристоф Лихтенберг; Генрих Герц; Определенность смысла; Произведения и миры; Перспективные модели

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INTRODUCTION TO THE INTRODUCTION

There has been increasing interest in recent years to adopt hermeneutical methods and approaches in studies of science and technology. A previous issue of this journal testifies to this (Wu & Luo, 2024) as do several workshops and discussion groups, important monographs (Kudina, 2023), or the proposal to pursue „hermeneutic Technology Assessment" (Nordmann & Grunwald, 2023). To be sure, some of these discussions take up and develop earlier suggestions from the philosophical tradition (e.g., Paul Ricoeur, 1973, or Don Ihde, 2023), others strangely forego any explicit mention of hermeneutics such as a prominent research program on „scientific understanding" (de Regt et al., 2013).

With all the excitement about hermeneutics of science and technology, it is easy to forget that, interestingly, such an endeavor or line of questioning should not even exist. Going back to Wilhelm Dilthey and his famous juxtaposition of *Erklären* (explanaining) and *Verstehen* (understanding), one would be taken away from science and technology when one embarks on a quest for understanding and when one becomes absorbed in the practice and process of *Verstehen.* Leaving the sphere of direct and transparent or technical communication, one would be entering a different realm, namely that of art and the humanities (Dilthey, 2010).

It might therefore prove valuable and will heighten the interest and relevance of the hermeneutics of science and technology if we step back and ask how it is even possible, that is, how it overcomes the „original antagonism" of science or engineering and hermeneutics. This serves to query and perhaps to establish the background, the rationale, or even the „foundations" of this decidedly non-foundationalist intellectual enterprise. The authors of this special issue ask this question. In more and less incredulous ways they probe the very idea of a hermeneutics of science while others turn to the hermeneutics of technology, with yet others straddling the line, concerned with science and technology. This editorial provides a skeptical backdrop and moves slowly from there. Under the impression of the „original antagonism" and the reasons that gave rise to it, it exhibits some of the hermeneutic pathways that were pursued during the last forty years by one of the editors of this special issue. That he presents himself as a case-study of the struggle for hermeneutic perspectives may serve as an excuse for excessive self-citation.

If nowadays it appears easy to adopt a hermeneutic stance in the study of science and technology, this is because historical contextualization and societal integration have become commonplace. The humanities no longer approach science and technology with respect for what it is or pretends to be. What used to be condemned as deconstruction, even subversion of the peculiar authority of scientific knowledge is nowadays no more than a comprehensive appreciation of scientific and engineering practice. The hermeneutics of science and technology grew up, tentatively, at the border beween the humanities (*Geisteswissenschaft*) and the sciences of nature and craft (*Natur- und Ingenieurwissenschaft*). Probing just how permeable that border proves to be, the hermeneutic stance has by now confidently absorbed scientific and engineering as just some among many world- and sense-making practices. These are no longer considered categorically distinct from the arts and the creation of fictions, thus reversing the divisions that had been instituted in the 18th and still dominated the 20th century.

ORIGINAL ANTAGONISMS

Hermeneutics was and is primarily concerned with the life of the mind as it is expressed in religious, legal, and literary texts as well as works of art. These texts and works require exegesis. As outlined by Friedrich Schleiermacher, Wilhelm Dilthey, Hans-Georg Gadamer, or Paul Ricoeur, the hermeneutic process and the practice of exegesis require that we enter the work as a composition of symbols or elements, and thus as a world onto its own. Within the horizons of this world we recover meaning, we make sense – and after this encounter we do not leave quite as we entered. As opposed to the knowing subjects of scientific research, the subjects of hermeneutic exegesis do not remain unchanged in their course of inquiry.

If this is a general characterization of hermeneutics, it appears to exclude scientific texts as well as technical works. It is precisely the achievement and perhaps the essence of so-called „normal science" that scientific texts might interpret data and explore the meaning of theories, but the texts themselves do not require exegesis by other scientific readers. Science pursues an image of knowledge that emphatically excludes the need for exegesis. If there is nevertheless a hermeneutics of science, this is because the quest for transparency and the exclusion of exegesis need to be understood as well: how do scientists as readers and writers achieve the seemingly unproblematic intelligibility of their texts? Three examples may serve as different models for a hermeneutics of science that is consistent with the view that scientific reading and writing does not require hermeneutics.

Much more recent, and therefore perhaps even more interesting, is the question of a hermeneutics of technology. How much of a stretch is it to consider sense-making in respect to clocks, assembly lines, fireworks, or wastewater infrastructures? The hermeneutic approach to technology begins by undermining the distinction between works of art and works of technology. As we contemplate a machine or participate in its workings, do we also enter the work as a world onto itself, seeking orientation within the horizon of the work, allowing ourselves to be transformed by this experience? Again, some exemplary approaches are offered to answer this question.

HERMENEUTICS OF SCIENCE

According to Gaston Bachelard, the task of the philosophy of the science is to elucidate the difference between science and poetry: "All that philosophy can hope to accomplish is to make poetry and science complementary, to unite them as two well-defined opposites" (Bachelard, 1987, p. 2). Hermeneutics does not provide the criteria for this distinction – it *is* the distinction since poetry is nothing without hermeneutics and science succeeds only to the extent that it does not require hermeneutics. In other words, hermeneutics is implicated in the process of differentiating science and poetry. This is mirrored also in the literary ideals and conventions of the philosophy of science (Nordmann, 2011). Here are three ways in which hermeneutics *is*, indeed, implicated in this process.

Scientists often „interpret" data, they also offer interpretations of theories, such as the famous interpretations of quantum mechanics. They do not, however, interpret each other in what they say and write. Scientists do not usually ask „what did you mean when you used this word in this context?“ and they do not say: „this turn of phrase opened my eyes, I suddenly look at the world in an entirely different way.“ Consider one of the few examples of a simple elegant phrase of scientific writing opening the door to a whole new way of doing science. When James Watson and Francis Crick first revealed the double helix, they concluded their short analysis of the molecular structure of DNA by writing: „It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanisms for the genetic material“ (Watson & Crick, 1953, p. 737). Tellingly, however, even this magnificent example of world-making scientific prose presupposes a prepared mind – that the readers immediately recognize and understand the meaning of what they are only hinting at.

Indeed, one might argue with Thomas Kuhn and others that the apparent transparency of language is a precondition of science – „we understand each other because we are speaking the same language.“ In other words: The sphere of scientific discourse is special in that it does not require hermeneutics. Inversely, there are stories about science breaking down when scientists do not speak the same language as in the Chemical Revolution of the 18th century.

If this is so, then *one* job for a „hermeneutics of science“ could be to study how this transparency is possible, how it is established and maintained. In personal relations, in politics, even in business and the law one often says „we do not understand each other even though we are speaking the same language.“ Perhaps it is only an illusion but science successfully maintains the conceit that *because* one speaks the same language, one will understand each other. One steps out of science (and into philosophy) by questioning a basic, albeit implicit tenet: The very fact of being socialized to use words in particular ways is sufficient to guarantee that no interpretation or translation of these words will be required by other speakers of the language.

There is another dimension to this. Philosophical hermeneutics considers the making of meaning as a process that involves how we understand ourselves. A powerful religious or literary text engages readers as persons who encounter propositions in a special horizon of meaning such that the „otherness“ of the text provokes them to expose their habituated ways of thinking and feeling – and thereby the readers may emerge as if ever so slightly altered beings. (This is one of the reasons, of course, why we should read literary texts.) There is none of this in science, supposedly. Scientists may come up with a changed understanding of nature but they are not looking to change themselves, to develop their character or grow as a person. They are what they always are: Impersonal knowing subjects who experiment and observe, perhaps interpret, and draw conclusions. Inversely, in a scientific revolution, scientists in different camps discover that they think, perceive and act differently – that a new kind of scientist is emerging along with a new paradigm. But this again is a moment of breakdown. Science proceeds only once this episode in the history of science can be bracketed or backgrounded and „normality“ returns.

To be sure, this program of a „hermeneutics of science“ would not actually engage in hermeneutics since it seeks to show why scientists do not need to adopt a hermeneutic approach. Instead, it would provide a transcendental reconstruction of the conditions under which hermeneutics is or is not required – how and when do humans become engaged with each other in the process of making meaning und understanding each other? And how do humans manage to define a sphere of public reason where shared meanings can be assumed along with a shared identity as scientists or citizens?

An exemplary case for this first approach comes from 18th century theories of electricity (Nordmann, 1986, 2021a). There was an empirically intractable debate about electrical fluids and electrical charge. Some argued that there are two fluids which are opposed to each other. Depending on which one prevails, one or another state of attraction or repulsion is induced or the forces cancel each other out. Others believed that there was only one fluid, sometimes too much of it, sometimes too little, again inducing three states of surplus or privation or a proper medium. Georg Christoph Lichtenberg discovered a phenomenon of which he thought that it might shed light on the debate (Fig. 1). He therefore proposed the neutral terminology of E+ and E-. The first of these terms – E+ or „plus E“ – can serve as the name of one of the two fluids *or* it could indicate the state of preponderance of the single electric fluid. The notion of plus and minus, positive and negative also captured that everyone agreed on the existence of a neutral state, a kind of „0“. As it happened, the new terminology established a common language. It mattered less and less what particular meaning anyone attached to the symbols – this was from now on a private, scientifically irrelevant question. Science could proceed without a debate about proper interpretation.

The case of Lichtenberg’s linguistic intervention nicely shows how scientists create and maintain conditions of intelligibility that exclude the need for hermeneutics. As such the case is not itself a part of a hermeneutical exercise of sense-making.

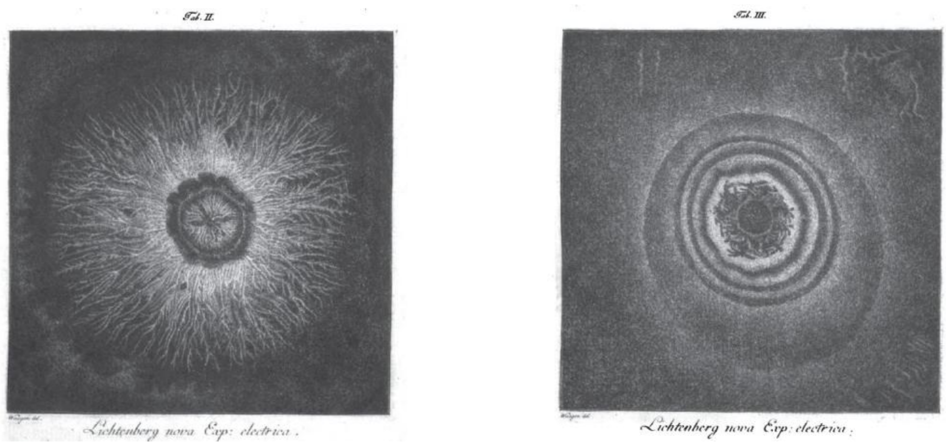

Figure 1. In his laboratory, Georg Christoph Lichtenberg produced miniature lightning strikes that discharged into a resin cake. When dust gathered on the cake, the discharge patterns became visible and they were different when positively and negatively charged. The Lichtenberg Figures became a scientific toy, with their many branches reminiscent of ice crystals and illustrative of a complex dynamics. Lichtenberg used them as a new method of writing and they later proved important for the invention of xerography, but do they also hold the key to understand the nature of electricity – two opposed electrical fluids or surplus and deficit of just one fluid? (Lichtenberg, 1779, compare Baird & Nordmann, 1994, Nordmann, 1986 and 2021a)

But then there is another role, a *second* possible job for the hermeneutics of science. Different interpretations of the data and also of theories are always possible, but often they are not mere interpretations as they suggest testable empirical implications. This allows for experimental evidence to settle questions of interpretation. Here again, the hermeneutic question of meaning arises only in a temporary, tentative, preliminary way. Such questions may be a part of science but mark a state of uncertainty and indeterminacy of meaning that needs to be overcome. On the other hand, this state will always reappear. There is thus a dialectic at work. When a theory is „interpreted," its empirical meaning is questioned. An experiment serves to specify the physical meaning and puts an end to speculation. The experiment simultaneously determines features of the world and the meaning of the descriptive vocabulary.

This tension between hermeneutic questioning and empirical determination – where one can give rise to the other, and where the latter puts an end to the former – appears in the works of Heinrich Hertz as one of „philology" (idle disagreements about words) and „philosophy" (the fixation of determinate physical meaning). Hertz cherished the times when the scientist in the laboratory is „alone with nature" – only then a true scientist. As soon as Hertz would publish his work, his findings become subject to philology. Different, empirically equivalent models can then be constructed to account for and interpret his findings, often without any presently available means to put them to a physical test. This was the state in which he found Maxwell's equations, proclaiming that „Maxwell's theory is the system of Maxwell's equations." In other words, physics proper cannot say anything more about the meaning of the terms in those equations than what is implied by the equations themselves. Hertz himself brilliantly exposed this by contrasting different interpretations of the equations (Hertz, 1893, pp. 20-28). But then, as an experimentalist alone with nature, he famously discovered radio waves and summarized this discovery by stating that the most important result of his experiments was the „philosophical" result of specifying the physical meaning of Maxwell's equations (Hertz, 1893, p. 19, see Nordmann 1998, 2009). To be sure, having done this, Hertz noted with some regret that rivalling interpretations of his discovery were offered – back to the philological condition where meanings become indeterminate.

Here, the task of hermeneutics is to trace the dialectical movement between the „philological" phase of indeterminacy of meaning to the (always superior) „philosophical" phase of the physical determination of meaning. The philological phase is then one of degeneracy and corruption (see Horgan, 2015). It is therefore a mark of progress when one can overcome this phase, establishes clarity of meaning and thus beliminates the need for hermeneutics.

There is quite another approach or *third* job for the hermeneutics of science which cannot be summarized easily. It was proposed by Margaret Morrison and Mary Morgan, and elaborated especially by Nancy Cartwright (Morgan & Morrison, 1999; Cartwright, 1983, 1989, 1999, see Nordmann 2008).[1] Of the three approaches presented here, only this one shows hermeneutics to be an essential part and not just the dialectical „poetic other" of science. On this third approach, it is not *people* (the scientists, readers) who

[1] Cartwright did not use the word „hermeneutic" but responded very favorably to the suggestion that there are central hermeneutic moments in her philosophy of science (Cartwright, 2008).

interpret theory or interpret data. This is what *models* do and models interpret theory and data simultaneously. Models are mediators and „autonomous agents“ in that they do hermeneutic work – they achieve physical interpretations of theories by forging a fit between interpretable data and interpretable theories. By the way in which models relate features of theory and data, models show us how to „understand“ the data in light of the theory, and to „understand“ the theory in light of the data – they do so in a non-circular but also not independently testable manner by way of adaptation, calibration, or tuning. Models are sense-making devices. The criteria for the acceptance of models are not separate from those for the acceptance of the relevance of data and the acceptance of the „truth“ of theories. In the end – through patient work – calibration or attunement or „proper fit“ can be achieved, and this is a hermeneutic achievement. As opposed to the case of literature and art, it is not the readers or beholders who change in the process of sense-making or appropriation, but here it is the models that change since they are the hermeneutic agents of interpretation and with them their data take on new meaning as well as their theory. – But here again there comes a time when the hermeneutic process is over and done with. Once the model establishes a reasonable fit, it enables scientists to move between the levels of description, modelling, and theory back and forth with considerable ease. Again, a kind of transparency is achieved and a seemingly straightforward mapping relation: This achievement backgrounds or renders invisible the hermeneutic work of the model as mediator.

In order to find examples for this, one might turn to the current discussions of „fictionalism“ which can be traced back to Hans Vaihinger’s *Philosophy of the ‘As If’* (Vaihinger, 1935) but also to Nancy Cartwright’s *How the Laws of Physics Lie*. In that book she tells the story of „physics as theatre“: In order to truthfully represent a historical event on stage one needs to obey the requirements that come with the adopted representational framework of the theatre. These may require distortions of fact. If one wants to show how two persons conspire during a big assembly, one cannot have them whispering to one another during the proceedings. Instead, one has to come up with a way to send everyone else off stage to leave the conspirators alone for a while. This is not how it actually was and thus introduces a fictional element, but only with that fictional device can the story of the conspiracy be told (Cartwright, 1983, p. 140). Fictions can therefore serve as tools that foreground salient features. In other words, fictionalism is not about telling the truth by telling the right lies – there cannot be such a thing as a lie that is right (which is why some people find fictionalism scandalous). It is instead about telling lies rightly, that is, in the right kind of way such that acknowledged falsehoods can function as tools for foregrounding some truth. There never was a Prince of Denmark called Hamlet. Without claiming otherwise, the blatant fictional invention of that prince can serve to showcase truths about hesitation and doubt in the pursuit of justice or revenge. The system of lies or the representational scheme has some agency in that it can disclose or uncover meaningful structural relations in what might be called a hermeneutic process – *reading* through a specific set of glasses that exaggerate or distort and thereby render visible what would otherwise go unnoticed.

This concludes for now the discussion of the hermeneutics of science. To be sure, it was far from comprehensive. It failed to appreciate Patrick Heelan’s attempt to establish a hermeneutic philosophy of science. Under the impression of quantum mechanics it was meant to pursue questions of meaning and truth in science (Heelan, 1998). Also, in quite another register, this review could have considered Hasok Chang's idea of "complementary science": Chang offered a hermeneutics of „temperature" in order to make concepts and strategies from the history of science available to contemporary science (Chang, 2004).

If these are but two of many omissions, there are more principled reasons for not considering two large areas of contemporary discussion. There is firstly the recent interest in understanding „scientific understanding." De Regt and other participants in this endeavor stay clear of „hermeneutics" and the whole tradition of *Erklären vs. Verstehen* (de Regt et al., 2013). The reason for this is simple enough and excludes them from consideration in this context. They want to characterize „understanding" as a particular state of knowledge, mostly in terms of capacity or skill. For example, a criterion of understanding might be that no explicit inferences or calculations are needed when using a theory to predict the behavior of some physical system. There is no interest either in the process of sense-making or the conditions of intelligibility and mutual understanding.

Then there is the interpretive work performed by historians of science who read scientific texts like any other kind of document that requires a reconstruction of its implied world-view or paradigm (Kuhn, 1962). While some of the contributions in this special issue are inclined to take this as indicative for a hermeneutics of science, in an of itself it confirms and does not undermine the original antagonism. If it is a defining characteristic of „normal science" that the shared paradigm relieves scientists of the task to perform hermeneutic work, historians of science re-open the black box by engaging in this task. For the most part, historians of science do not operate within a shared scientific paradigm. Thus, by having to recover what scientists mean to say, they simultaneously deconstruct and reconstruct the achievement of apparent transparency of meaning. The historian's hermeneutic work thus undoes what the paradigm is supposed to provide, it walks back the constructions of objectivity and conditions of determinacy of meaning. By problematizing what „normal science" takes for granted, historians begin from a position of antagonism to normal scientific practice. And by performing hermeneutic work this historiographic hermeneutics of science adopts a stance that needs to be bracketed by the scientists themselves: One needs to step out of science in order to do history or so-called hermeneutics of science. In the words of physicist and philosopher Carl Friedrich von Weizsäcker (1981):

> It is inherent in the methodological principles of science that certain fundamental questions are not posed. Physics, as it is practiced in modern times, characteristically does not really ask what matter is, biology does not ask what life is, and psychology does not ask what the soul is; instead these terms just vaguely circumscribe the area one intends to investigate. This fact is probably methodologically fundamental to the success of science. Were we to pose these most difficult questions while at the same time practicing science, we would lose the time and energy needed to solve the solvable questions. […] On the other hand, we must not deceive ourselves: the methodological procedure of science just characterized has something murderous in it if it no longer knows how

> questionable it is. The questions are difficult, but they are not unimportant. Heidegger's formula "Science does not think" can hardly be quoted to any scientist without provoking anger. In Heidegger's sense of the word "think," however, the formula is literally correct. For Heidegger takes "to think" as meaning "to put oneself in question once more," and precisely this science will not do in its normal practice. (p. 233)

Hermeneutics enters the world of a text or of art, more generally, in the way of thinking, that is, by putting oneself in question. In contrast, E+ and E- brackets the need to ask what electricity is. The experimental demonstration of radio waves finally puts to rest the philological debate about the physical meaning of a term in Maxwell's equations and settles the question of "action at a distance." Hermeneutics here serves to exhibit the processes by which science attains. If there is a hermeneutic of science and not just a hermeneutic historiography or philosophical reconstruction of science, we found it in the technical process of modeling as a mutual attunement of theory and reality by way of the model as mediator or hermeneutic device. This intermediary conclusion leads on to conceptions of a hermeneutics of technical works, including models as material compositions that establish what can be done in the fields of theory and practice (Nordmann, 2025).

HERMENEUTICS OF TECHNOLOGY

According to Gernot Böhme, all technical devices or socio-technical systems are models of social processes, they model the ways in which we intellectually and materially appropriate nature and society which we do by making things work for us in reliable and beneficial ways (Böhme, 2012, p. 21-22, see Böhme, 1993, p. 453-454). They are mediators and translators of sorts. Marco Tamborini (2022) builds on this by relabeling *homo faber* as *homo translator* – translating from the language of nature into the language of technology, as witnessed most explicitly in the case of so-called biomimetic technology. A famous example of biomimetic technology is Velcro: in the sphere of technology it takes up or reproduces how some things are done in the sphere of biology. Now, is this „mimicry" actually a hermeneutic process of sorts? The Velcro device makes sense of how a burr becomes attached to the fur or an animal. It makes sense, however, not by copying the original but by way of parody: It exaggerates what the burr does and reflects on the original by being raw or crude instead of sophisticated and subtle (Nordmann, 2021b). Velcro is a way of „reading" biological nature – it seeks its place within the horizon of the book of nature, materially fitting itself among all the other natural and technical things. However, each a world onto its own, all these things remain external to each other, questioning each other, or commenting.

Hermeneutics is a practice of reading that constitutes the meaningful world of a text, be it a prophetic or biblical, even legal text, be it a literary work or a work of fine and technical art.[2] The world we constitute through our hermeneutic practice is and isn't

[2] Compare this and the following couple of paragraphs to "Machine Hermeneutics" (Nordmann, 2023) which outlines the prospects for a hermeneutic approach to technical devices.

our world – this is what it means to say that reader and text are external to each other, that they do not blend seamlessly but question each other. Even Gadamer's so-called "fusion of horizons" does not refer to fusion or identification but to the creation of conditions for a shared understanding from different points of view (Gadamer, 2013). There is no perfect transparency of meaning but a material irritation or resistance – the relation of original and copy, of representations and what they represent is disturbed, distorted, or obscured – another reason for distinguishing the production of true representations from hermeneutics as a process of understanding oneself by encountering and never quite understanding the other. The world thus constituted is and isn't our world also in the sense that we invest ourselves in our world by making meaning. At the same time it is not our world because it is the world of a text or of nature or of a created work that resists appropriation. It cannot be integrated seamlessly into the experiences, ideas, expectations of our daily lives, it cannot be absorbed entirely, and does not dissolve into our ordinary ways of sense-making. The world of a literary text or work of art – including technical works – never becomes quite familiar but retains a sense of strangeness, unfamiliarity. In the meantime we inhabit a life-world which also is and isn't our world. It is ours because we live and act in it, it is familiar. It is not ours because we were cast into it and it is co-produced by countless human and non-human actors, with an uncertain future over which we have only very limited control even in our private lives. This meeting, blending, fusing of different, even antagonistic literary and life-worlds makes for what one might call a hermeneutic encounter. We are so deeply implicated in this encounter that we cannot withdraw to the safe place of the observer or interpreter who casts out a net and retrieves some kind of account of what is said in a text and what it means. For the purposes merely of interpretation the reader is the measure of all things, recovering meaning on his or her own terms. In contrast, the reader is subject as well as object, agent as well as patient in the hermeneutic process – when I read a literary work, philosophical or legal text, the text happens to me just as much as I happen to the text.

If hermeneutics encompasses all of that, what does this signify for the hermeneutics of technology? The first impulse is to shift to discourse or text since there is much talking *about* technology in our societies. In particular we are drawn to technological visions as they are articulated by advocates and critics of emerging technologies, asking what this tells us about ourselves. By choosing to read government policies, calls for proposals, ethics reports, TV documentaries, NGO position papers as if they were literally texts, we become implicated in a societal conversation about anxiety and hope, visionary confidence and dystopic doubt about the technologies of the day. This is one way, for sure, to study the world we live in, though this is usually done from the safe place of the analyst or cultural critic and does not involve the hermeneutic process as described above.

However, as we have seen already, it is not the exclusive privilege of texts that they constitute a world for a reader to enter. Technical works are worlds in their own right, and we enter them as well – these include needleworks, artworks, musical and literary works as technical achievements, poetically brought forth by human ingenuity and labor. If works are worlds, this includes no less the world of the clockwork, the world of metal works or water works, that is, the world of the factory. There is now also, very prominently, the world constituted by electronic as well as social networks, that is, the worlds that correspond to socio-technical systems. To the extent that every technical process or device draws together material things as well as human developers and users, they can all be considered as worlds that result from the composition, literally “putting-together” of numerous elements.

Do designers and users enter these worlds as readers do a text? Readers or not, we seek orientation, hope to establish and maintain a measure of control, and contemplate the meaning of these works. Cosmological questions as to who we are in the world are raised by Dürer’s Melancolia, Picasso‘s Guernica, and Malevich’s Black Square, but no less so by Tatlin’s tower or an 18th century astronomical clock that shows seconds and minutes, hours and days, months and years, and that exhibits the heavenly mechanics of the sun and the moon and the planets in their orbits (Fig. 2). A tower is a practical structure and so is the astronomical clock, but they are objects of contemplation as well.

Figure 2. An 18th century model of a Ptolemeian universe with the Earth at its center, a „world machine“ that is operated by a crank, and an elegant piece of furniture, an object of contemplation: Armillary Sphere of unknown origin, purchased in London around 1790, Hessisches Landesmuseum Darmstadt. For a discussion of similar devices see Baird and Nordmann, 1994.

A hermeneutics of technology might be concerned, therefore, with the world of technical works – what they signify about the ways in which humans and things can live and work together. When archaeologists find a vase or bronze axe, they begin to reconstitute the ways of life and modes of production which might have resulted in this or that particular glaze. They come up with a world that is dissociated from our own world of daily lived experience – and it is important not to simply assimilate these separate worlds as they can inform and critique each other. In the temporal order, a prototype is the complement to the archaeological artefact. It is also not of our time, and though we can see it right before our eyes, it is emphatically not of our world. If archaeological artefacts are *no longer* part of our world, or only as relics, prototypes are *not yet* part of our world or only as prospects. Similarly, the world of a prototype – of an artefact that supposedly heralds a future world – is not a mere extension or projection of our present world. Nor does it signify a latent world which only awaits to be realized. By claiming a way of being and doing things, these prototypes signify an alternative world which stands in an uneasy, as yet unresolved relation to our present world as we know it. How the present connects to the world of the archaeological artefacts is a question of hermeneutics, of telling a story which does not represent „the past“ but constructs this pathway and connection and thus implicates ourselves – we change and become someone different in the telling of this story. And how our present world connects to the world signified by the prototype is also a question of hermeneutics, of telling a story which does not represent the future but claims a prospect – not a possible future world but a model for reenactment, a world for the making (Nordmann, 2025). If the prototype is a model for enacting in the real world what so far is only a construct or concept, this invitation and prospect implicates us. We change and become someone else by accepting or declining the invitation, though who or what we might become lies far beyond the design ambitions that produced the prototype.

We have so far assumed, fairly unproblematically, that technical works are like works of art, but also assumed, more problematically, that a work is a world and that, categorically, it is like our world at large, only smaller. This calls for a reflection on the work as a world – a world that we enter, within which we need to find our way or seek orientation, and a world of happenings or goings-on, a working order of things in which we participate physically and intellectually. And if there are many such worlds as well as the world at large, what do we learn about being in the world, what do we learn about what a world is? How do we know a machine when we intellectually or haptically participate in the working order of a machine?

These questions are central to current concerns about digital technologies and AI (Bylieva, 2023a, 2023b). Entering into, participating in, finding ourselves in the midst of an ambient technological environment – all this figures under the heading of immersion in a digital system that changes the user and the technology. This is particulary evident in the mediation of „virtual“ and „real“ worlds, and the materially composed worlds of software and hardware. These worlds construct images of reality, for instance regarding the phenomenology of time. How long do pregnancies last in real and game times, how long until the bar on the computer display reaches across, indicating that a task is completed?

The hermeneutics of technology in this case can clearly show what different hermeneutic processes look and feel like. These differences leave traces, with diverging paths dependent on the user experience. From their own cultural and social backgrounds, users fit the technology into the contexts and practices of their life. This process changes the users themselves – habits, ways of thinking, perception of the world, even social connections. At the same time, modern digital technologies can respond to user interpretations, the act of use and interpretation changes the technology itself in its functional and semantic dimensions. The technology does not remain static: User patterns, unexpected ways of application (“workarounds”), support communities, public discussions, criticism, failure protocols, even deliberate misuse and behaviors that crash the system – all these becomes part of the "text" of the technology, redefining its meaning and impact. Self-learning systems or developers respond to this with updates and adaptations, which keeps modulating the user‘s world of experience..

Technologies can thus be understood in terms of their dynamic dialogue with the user. This also provides an expanded framework for researching and reflecting technologies. Each iteration of the hermeneutic circle renews the relation the elements and their whole, with the whole system refiguring the elements. Often enough this dynamics is not subject to conscious influence, unless the players know how to play the game, and steer in every so slightly to reflect their interests and desire. This form of interpretation of a technical system does not necessarily involve adaptation to it; sometimes, users will repurpose or destroy the “technological text.” Importantly, such rewriting and rethinking of the technologies leaves traces of the "divergent paths" in the digital systems themselves.

Moving to a more general level, the question of works as worlds calls for a separate paper. Beginning with Francis Bacon, it would feature Ludwig Wittgenstein as a central figure, and it might be rounded off with a consideration of Johan Huizinga‘s „magic circle“ that circumscribes a rule-bound world of play.

A brief consideration of Wittgenstein affords a short-cut (Nordmann, 2018, 2022). It reminds us of the difference between (hermeneutics of) science and (hermeneutics of) technology – where science is antithetical to hermeneutics while technological works invite hermeneutics no less than art-works do.

Readers of Wittgenstein’s *Tractatus Logico-Philosopicus* will encounter two conceptions of „world.“ One of these appears famously in the very first sentence of the book, the other is central to the equally famous „mystical“ ending of the book. The first sentences read: „The world is all that is the case“ – „The world is the totality of facts and not of things (Wittgenstein, 1922, remarks 1. and 1.1.). The other conception is distinctly different: „The feeling for the world as a limited whole is the mystical feeling“ (Wittgenstein, 1922, remark 6.45).

The world as the totality of facts is the world of science. There are indenumerable many facts, each of these facts is a contingent state of affairs: The fact exists but could be otherwise, and so the sentences that represent the facts can be true or otherwise. Itemizing and organizing the facts is the same as producing and organizing all true statements about the world. There are clear criteria for the truth of such descriptive statements – and no hermeneutics is required for thus producing a description of what is true in the world that is all that is the case.

But then, one can also contemplate and have a feeling for the world as a limited whole. In contrast to the scientific outlook on the world, to have a feeling for that whole is the mystical feeling. It is tempting to see this as a statement about religious transcendence. Beholding the whole of our world aesthetically, from a contemplative distance and as God would, one is struck by a mystical feeling of wonder and admiration. But the reader of Wittgenstein‘s notes can quickly spot Wittgenstein, the engineer. He wonders whether it is silly to contemplate the stove in his room, and rejoins that it is not silly at all because while he contemplates the stove, the stove is his world, after all

(Wittgenstein, 1961, entry dated 8.10.16). More importantly regarding the faultline between the worlds and between science and technology, Wittgenstein notes just before the remark on the stove: „As things among things, all things are equally insignificant, as world they are all equally significant“ (Wittgenstein, 1961, entry dated 8.10.16). It is isolated things and the facts about the things that, due to their contingency and their truth-conditions, render all statements „*gleichwertig*,“ that is, of equal value and thereby insignificant (see Wittgenstein, 1922, remark 6.4). Things assume value only when they contribute to a working order, to a whole, or to a world – and to be sure, for a mere thing to be valuable, it becomes mystical.

In a working order, things form a world in which each has value and each is significant: „It can‘t be that there is an ordered world and then also an unordered world, which would allow us to say that our world is orderly. Instead there is in every possible world some, perhaps complicated order“ (Wittgenstein, 1961, entry dated 19.9.1916). To have a feeling for the world is to have a feeling for how things work in this more or less complicated order. For the biologist Barbara McClintock this was described as a „feeling for the organism“ (Keller, 1984). but many tinkerers and engineers have a „feeling for the mechanism.“ To understand a theory or system of equations one needs a feeling for the algorithm, a feeling for model dynamics, parameter dependencies etc. This feeling is mystical because it cannot be reduced to mere descriptions of one fact at a time. It requires participation in the workings of a thing. Any magical worldview relies on participation which is not identification or becoming one with a system or thing, but involvement in a hermeneutic process that negotiates externalities through feedback, through settlement on a way of doing things. By being subject and object, agent and patient we run up against the limits of our world, including the artworks as worlds that look back at us, including the technical works as worlds that demand from us sometimes more than we demand from them.

HERMENEUTIC DIMENSIONS OF SCIENCE

Despite hermeneutic approaches in the historiography, reflection, and reconstruction of science, and despite hermeneutical moments which are often signs of crisis, science remains antithetical to hermeneutics while technological works invite hermeneutics no less than artworks do. The papers in this special issue struggle with and against this „original antagonism“ of science, while others offer perspectives for a hermeneutics of technical works.

Considering science as a project through which humanity expresses itself, Ilya Kasavin (2025) proposes a revision of the role of taxonomy in biology. He treats taxonomy as a hermeneutic practice, producing a fiction that affords intellibility. To demonstrate that the human dimension of sense-making is inseparable from scientific objectivity, an example of “interpretive flexibility” is given in the history of the division of the rodent (Rodentia) and lagomorph (Lagomorpha) orders.

Walker Trimble (2025) defends the role of metaphors in science, even where they might be replaced by more concrete expressions. A study of metaphors for cooperation in biology shows that these provisional expressions illuminate only seemingly distant relations.

Criticizing the idea of an original antagonism between hermeneutics and the interpretation of scientific texts, Anna Sakharova (2025) shows that interpretation is an integral part of the construction of theories. As prime examples she considers opposing theories in various fields of science. Sakharova argues that hermeneutics reveals the “second layer” of the text – the values, traditions, implicit rules that constitute science as a social institution.

Alexandra Argamakova (2025) considers hermeneutic practices as integral to scientific activity. Scientific models show scientists how to “understand” data in light of theory, acting as hermeneutic agents of interpretation. Pluralistic views on theory formation give rise to alternative conceptual frameworks. Various classifications (galaxies or biological species) depend on the pragmatic goals of scientists. All this warrants the application of hermeneutic methods in science.

Generally agreeing that there is no place for hermeneutics in science, Alexander Antonovskiy (2025) goes on to show which aspects of science leave room for it. In particular, he notes “hidden worlds” associated with unobservable entities, the aesthetic aspect, the presence of a specific language of the scientist, as well as a personal history of victories and disappointments.

Alina Kostina (2025) reveals the hidden dimension of power through the hermeneutics of science. She shows how scientific institutions use hermeneutics as an instrument of metapolitical control, preserving the myth of the neutrality and autonomy of science. Kostina argues that the hermeneutics of science provokes resistance because it exposes technocratic hierarchies.

The paper by Konstantin Frolov (2025) introduces a distinction between “soft” and “hard” hermeneutics, where the latter is associated with self-reflection. Frolov focuses on the role of the personal dimension in scientific knowledge and shows that interpretation implicates the knowing subjects and thus the researchers themselves.

HERMENEUTIC DIMENSIONS OF TECHNOLOGY

Marking the transition to the second group of papers, Evgeniy Maslanov (2025) offers a practice-oriented approach to the hermeneutics of science and technology. The author focuses on the micro level of scientific activity – the training of scientists, interdisciplinary collaboration, and work with technologies – demonstrating that hermeneutics is integrated with routine research practice. Hermeneutics is required for the interpretation of research methods, especially where these involve tacit knowledge, technological routines, or expermental procedures.

Yingyu Zhu (2025) offers a general argument for the hermeneutics of technology by demonstrating the priority of technological understanding. After discussing the distinction between scientific explanation and scientific understanding, she considers how technological understanding exceeds technological explanation.

Adopting a phenomenological-hermeneutic approach, Viet Anh Nguyen Duc (2025) focuses on the symbolic dimension of technical artifacts and how it is experienced.

The symbolic dimension may be concealed, remain in the background, conceal itself, or provoke reflection.

Liana Tukhvatulina (2025) suggests using the hermeneutics of technology for legal forecasting and for working through legal uncertainties. The article shows that conflicting "images of the future" collide within the framework of legislation devoted to new technologies

Finally, seeking to explore the novelty of a hermeneutics of technology, Olga Stoliarova (2025) engages in a dialogue with AI. Asking for novel concepts, she receives answers that appear thoughtful and original at first sight but prove to merely summarize familiar approaches. She does not hold this against the AI system, however, since it exemplifies the familiar predicament that innovation is a reprocessing of what is already available. Such reprocessing and the AI system can still engage us in ways of questioning and reconstituting ourselves.

REFERENCES

Antonovskiy, A. (2025). Hermeneutics of Science – Technical Assessments and Hidden Horizons of Meaning. *Technology and Language, 6*(2), 70-80. https://doi.org/10.48417/technolang.2025.02.06

Argamakova, A. (2025). Hermeneutic methods in science. *Technology and Language, 6*(2), 58-69. https://doi.org/10.48417/technolang.2025.02.05

Bachelard, G. (1987). *The Psychoanalysis of Fire*. Beacon Press.

Baird, D., & Nordmann, A. (1994). Facts-Well-Put. *British Journal for the Philosophy of Science, 45*, 37-77.

Böhme, G. (1993). *Am Ende des Baconschen Zeitalters* [At the End of the Baconian Era]. Frankfurt: Suhrkamp.

Böhme, G. (2012). *Invasive Technification: Critical Essays in the Philosophy of Technology*. Bloomsbury Academic.

Bylieva, D. S. (2023a). Virtualizatsiya beremennosti: igra i realnost [Virtualization of Pregnancy: Game and Reality]. *Chelovek, 34*(6), 100-119. https://doi.org/10.31857/S023620070026670-4

Bylieva, D. (2023b). A Semiverse of Games. In D. Bylieva & A. Nordmann (Eds.), *The World of Games: Technologies for Experimenting, Thinking, Learning. PCSF 2023. Lecture Notes in Networks and Systems* (vol 830, pp. 18–26). Springer. https://doi.org/10.1007/978-3-031-48020-1_2

Cartwright, N. (1983). *How the Laws of Physics Lie*. Oxford University Press. https://doi.org/10.1093/0198247044.001.0001

Cartwright, N. (1989). *Nature's Capacities and their Measurement*. Clarendon.

Cartwright, N. (1999). *The Dappled World: A Study of the Boundaries of Science*. Cambridge University Press.

Cartwright, N. (2008). Reply to Alfred Nordmann. In S. Hartmann, C. Hoefer, & L. Bovens (Eds.), *Nancy Cartwright's Philosophy of Science* (pp. 389-391). Routledge.

Chang, H. (2004). Complementary Science. In H. Chang, *Inventing Temperature* (pp. 235–250). Oxford Univ Press.

de Regt, H., Leonelli, S., & Eigner, K. (Eds.). (2013). *Scientific Understanding: Philosophical Perspectives*. University of Pittsburgh Press.
Dilthey, W. (2010). *Understanding the Human World*. Princeton University Press.
Frolov, K. G. (2025). Soft and Hard Hermeneutics of Science and Technologies. *Technology and Language*, *6*(2), 91-99. https://doi.org/10.48417/technolang.2025.02.08
Gadamer, H.-G. (2013). *Truth and Method*. Bloomsbury Academic.
Hertz, H. (1893). *Electric Waves*. Macmillan.
Heelan, P. (1998). The scope of Hermeneutics in Natural Science. *Studies in History and Philosophy of Science Part A 29*(2), 273-298. https://doi.org/10.1016/s0039-3681(98)00002-8
Horgan, J. (2015). *The End of Science*. Basic Books.
Ihde, D. (2023). *Material Hermeneutics: Reversing the Linguistic Turn*. Routledge.
Kasavin, I. (2025). Taxonomy: Reading the Biological Diversity. *Technology and Language*, *6*(2), 21-30. https://doi.org/10.48417/technolang.2025.02.02
Keller, E. F. (1984). *A Feeling for the Organism: Life and Work of Barbara McClintock*. Times Books.
Kostina, A., (2025). Hermeneutics of Science: New Metapolitics of Institutional Order. *Technology and Language*, *6*(2), 81-90. https://doi.org/10.48417/technolang.2025.02.07
Kudina, O. (2023). *Moral Hermeneutics and Technology: Making Moral Sense Through Human-Technology-World Relations*. Lexington Books, Rowman & Littlefield.
Kuhn, T. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
Lichtenberg, G. C. (1779). *Zweite Abhandlung über eine neue Methode, die Natur und die Bewegung der elektrischen Materie zu erforschen* [Second treatise on a newmethod of studying the nature and motion of electrical matter]. In *Commentationes Societatis Regiae Scientiarum Gottingensis*, *Classis mathematicae, tomus I, ad annum 1778* (pp. 65-79). Göttingen.
Maslanov, E. V. (2025). Hermeneutics in Research Practice. *Technology and Language*, *6*(2), 100-108. https://doi.org/10.48417/technolang.2025.02.09
Morgan, M. & Morrison, M. (1999). *Models as Mediators: Perspectives on Natural and Social Science*. Cambridge University Press.
Nguyen Duc, V. A. (2025). On the Symbolic Dimension of Technology: A Phenomenological Approach. *Technology and Language*, *6*(2), 127-141. https://doi.org/10.48417/technolang.2025.02.11
Nordmann, A. (1986). Comparing Incommensurable Theories: A Textbook Account from 1794. *Studies in History and Philosophy of Science*, *17*(2), 231-246. https://doi.org/10.1016/0039-3681(86)90027-0
Nordmann, A. (1998). “Everything Could Be Different”: The Principles of Mechanics and the Limits of Physics. In D. Baird, R.I.G. Hughes, A. Nordmann (Eds.), *Heinrich Hertz: Classical Physicist, Modern Philosopher* (pp. 155-171). Kluwer.
Nordmann, A. (2008). “Getting the Causal Story Right”: Hermeneutic Moments in Nancy Cartwright’s Philosophy of Science. In S. Hartmann, C. Hoefer, & L. Bovens (Eds.), *Nancy Cartwright's Philosophy of Science* (pp. 369-388). Routledge.

Nordmann, A. (2009). Heinrich Hertz an den Grenzen seiner Wissenschaft [Heinrich Hertz at the Limits of his Science]. In A. Schwarz and A. Nordmann (Eds.), *Das bunte Gewand der Theorie: 14 Begegnungen mit philosophierenden Forschern (The colorful Garment of Theory: 14 Encounters with Philosophizing Researchers)* (pp. 133-153). Alber.

Nordmann, A. (2011). Philosophy of Science. In B. Clarke & M. Rossini (Eds.), *Routledge Companion to Literature and Science* (pp. 362-373). Routledge.

Nordmann, A. (2018). A Feeling for the Work as a Limited Whole: Wittgenstein on the Problems of Philosophy and the Problem of Technology. *Techné: Research in Philosophy and Technology*, *22*(3), 334-351. https://doi.org/10.5840/techne201812387

Nordmann, A. (2021a). First and Last Things: The Signatures of Visualization-Artists. *Technology and Language*, *2*(2), 96-105. https://doi.org/10.48417/technolang.2021.02.10

Nordmann, A. (2021b). Biotechnology as Bioparody – Strategies of Salience. *Perspectives on Science*, *29*(5), 568–582. https://doi.org/10.1162/posc_a_00384

Nordmann, A. (2022) Die schöne Technik der Verschwendung: Größte Kleinigkeiten [The Fine Technological Art of Wastefulness: The Greatest Minutiae]. In S. Maasen and D. Atwood (Eds.), *Immanente Religion - Transzendente Technologie: Technologiediskurse und gesellschaftliche Grenzüberschreitungen* (pp. 269-285). Budrich.

Nordmann, A, (2023). Machine Hermeneutics. (In Armin Grunwald, Alfred Nordmann, and Martin Sand (eds.) *Hermeneutics, History and Technology – The Call of the Future* (pp. 193-215). Routledge.

Nordmann, A. (2025). Prospective Modeling. In T. Knuutila, T. Grüne-Yanoff, R. Koskinen, & Y. Sjölin Wirling, (Eds.), *Modeling the Possible* (pp. 221-241). Routledge.

Nordmann, A. & Grunwald, A, (2023) Hermeneutic Technology Assessment – Why it is needed and What it might be. In A. Grunwald, A. Nordmann, & M. Sand (Eds.), *Hermeneutics, History and Technology – The Call of the Future* (pp. 37-41). Routledge.

Ricoeur, P. (1973). The Model of the Text: Meaningful Action Considered as a Text. *New Literary History*, *5*(1), 91. https://doi.org/10.2307/468410

Sakharova, A. (2025). Hermeneutics and science: taxonomies, interpretations, subjectivity. *Technology and Language*, *6*(2), 49-57. https://doi.org/10.48417/technolang.2025.02.04

Stoliarova, O. E. (2025). Techno-Contexts and the Birth of Novelty: Questioning the AI on Hermeneutics. Technology and Language. *Technology and Language*, *6*(2), 151-160. https://doi.org/10.48417/technolang.2025.02.13

Tamborini, M. (2022). Philosophy of Biorobotics: Translating and Composing Bio-hybrid Forms. *Technology and Language*, *3*(4), 143-159. https://doi.org/10.48417/technolang.2022.04.10

Trimble, W. (2025). Scientific Representation – Metaphor's Terrain. *Technology and Language*, *6*(2), 31-48. https://doi.org/10.48417/technolang.2025.02.03

Tukhvatulina, L. A. (2025). Hermeneutics of Technology and Anticipation of the Future in Law. *Technology and Language*, *6*(2), 142-150. https://doi.org/10.48417/technolang.2025.02.12

Vaihinger, H. (1935). *The Philosophy of ‘As if’: A System of the Theoretical, Practical and Religious Fictions of Mankind*. Kegaxn Paul, Trench, Trubner.

von Weizsäcker, C.F. (1981). *The Unity of Nature*. Farrar Straus Giroux.

Watson, J., & Crick, F. (1953) Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid. *Nature*, *171*, 737–738. https://doi.org/10.1038/171737a0

Wittgenstein, L. (1922). *Tractatus Logico-Philosophicus*. Routledge and Kegan Paul

Wittgenstein, L. (1961). *Notebooks 1914-1916* (G.H. von Wright and G.E.M. Anscombe, Eds.). Blackwell.

Wu, G. & Luo, D. eds. (2024). Hermeneutics: A Broadening Scope of Inquiry. *Technology and Language*, *5*(1), 1-6. https://doi.org/10.48417/technolang.2024.01.01

Zhu, Y. (2025). A Call for Technological Understanding. *Technology and Language*, *6*(2), 109-126. https://doi.org/10.48417/technolang.2025.02.10

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Research article

Taxonomy: Reading the Biological Diversity

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Abstract

The article deals with problem of application of the hermeneutical approach to understanding science and technology, which often faces a number of dead ends. In order to escape from them one needs a new vision of science. This helps understands science as a product of human creativity, which is hardly the representation but rather the construction of reality. Being so, it includes interests and values, aims and means, fantasies and desires. Scientific methods impose intellectual nets over nature that ascribe meanings to it. The case study of two main trends in biological systematics shows that natural biological diversity appears as a kind of unity ordered by classifications. A taxonomy grasping the structural unity represents a kind of artificial symbolic system, system of nomenclature based on the schematism of scientific imagination. Every taxonomy presents a "fictional," non-natural, human-dimensional, artificial picture of biological reality, but it is the such pictures that makes this reality understandable. And horizons of understanding oscillate between ontological, methodological and disciplinary structures of science. The prerequisite of the hermeneutical approach to natural sciences is understanding of science as a a humanist project. And the hermeneutical approach helps in turn enrich science viewing it as a creation of man. One enters here the hermeneutical circle, which is fruitful and provocative at the same time.

Keywords: Hermeneutics of science and technology; Interpretation; Science and humanism; Biological diversity; Biological systematics; Natural-artificial; Reality of taxon

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Научная статья

Таксономия: как читать биологическое разнообразие

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Аннотация

В статье рассматривается проблема применения герменевтического подхода к пониманию науки и техники, который часто приводит к ряду тупиковых ситуаций. Чтобы выйти из них, необходимо новое видение науки. Оно помогает понимать науку как продукт творчества человека, являющийся не столько представлением, сколько конструированием реальности. Таким образом, наука включает в себя человеческие интересы и ценности, цели и средства, фантазии и желания. Научные методы накладывают интеллектуальные сети на природу, приписывая ей смыслы. Ситуационный анализ двух основных трендов в биологической систематизации показывает, что естественное биологическое разнообразие предстаёт как некое единство, упорядоченное с помощью классификаций. Таксономия, охватывающая структурное единство, репрезентирует своего рода искусственную символическую систему, номенклатуру, основанную на схематизме научного воображения. Каждая таксономия представляет собой “вымышленную”, неестественную, человекомерную, искусственную картину биологической реальности, но это единственная картина, делающая эту реальность понятной. А горизонты понимания колеблются между онтологическими, методологическими и дисциплинарными структурами науки. Условием герменевтического подхода к естественным наука является понимание науки как гуманистического проекта. Герменевтический же подход в свою очередь способствует видению науки как человеческого творения. Мы вступаем здесь в герменевтический круг, который является плодотворным и провокационным в то же время.

Ключевые слова: Герменевтика науки и техники; Интерпретация; Наука и гуманизм; Биологическое разнообразие; Биологическая систематизация; Естественное-искусственное; Реальность таксона

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HERMENEUTICS – A NEW PROBLEMATIZATION

The problem-field of the article is an implementation of a hermeneutical approach to the natural sciences and technology. It It affords a new approach to representing the non-classical expansion of epistemological subject-matter and methodology. Yet there are many reasonable doubts about the legitimacy of this expansion since the opposition of two cultures (Ch. Snow) in science is still vivid and influential. Alfred Nordmann clearly articulates many of these doubts in his works, though at the same time he strongly encourages and endorses the search for the implementation of hermeneutical insights in science and technology studies. He noticed particular 'hermeneutic moments' in the scientific discourse.

> At these moments the models are the stage on which the negotiations take place and on which the top-down and bottom-up approaches become calibrated to each other. Moreover, [Nancy Cartwright's] hermeneutic characterizations treat the model not only as the site at which those negotiations converge, but in an interesting sense they turn the model into a protagonist of sorts, namely into a device that interprets, measures, or reads phenomena and theory and that promotes the attunement of concrete and abstract properties. (Nordmann, 2008, p. 372)

We shall see below how these considerations are applicable to understanding discussions in biological systematics.

Historically, the hermeneutical movement in philosophy arose as a search for meaning in texts and in the sciences deeply rooted in the life-world (*Lebenswelt*) (Dilthey, 1966; Gadamer, 1975). Conversely, technology has already been grasped as an application of human ends and means, abilities and desires, and hence open to the horizon of hermeneutical interpretation. However, the question if there are meanings to be discovered in the natural world outside the human one refers normally to the border between science and theology, naturalism and creationism. A proper example might be found in intelligent design theory (Numbers, 2006).

THE HUMANISTIC PROJECT OF SCIENCE – PREREQUISITE FOR THE HERMENEUTICAL APPROACH

The discovery of the human dimension of science, the understanding of science as a humanist project has considerable methodological significance in the given context: it contributes to the implementation of the hermeneutical approach to the natural sciences, at the same time excluding any supernatural mind. I single out three of such dimensions of science: history, values and communication (Kasavin, 2023). They reveal science's inseparability from culture and human agency and shape the sphere of meanings if not in the object of science, then at least in the scientific community and its knowledge claims.

The view of science as a way of communication, as an element of cultural history, as a moral challenge is the path to understand the capacity of scientific activity to build the life world, the genuine and unique surrounding of humankind. This surrounding in no way reduces humans to their natural Umwelt understood as mezzo-cosmos but rather contributes to the human unending quest to self-realization. Proposing to view science as a humanistic project, we enter the hermeneutical circle, in which science is able to comply with the values of humanism, and humanism itself is consistent with the pathos of scientific research. Today, reflections on humanism often fall in line with the analysis of the concepts of post- and transhumanism. This is especially the case when humanism is associated with modern science. Then the problems of humanism are actually identified with a new perspective of philosophical anthropology, i.e. a view of the future of humanity through the prism and promises made by science and technology of our days. But even this perspective cannot simply neglect the difficult question of the nature of the modernity in which we live and which shaped our societies.

Philosophy, no matter what it says, always speaks about human nature and destiny. What does it mean to be a modern person is the main question today. In the essay “On the Vocation of the Scientist,” Johann Gottlieb Fichte writes that philosophy begins with „the question of man“ in general, but ends with the project of that special person, the best of its kind – the man of science, the scholar or scientist, *der Gelehrte* (Fichte, 1864, p. 59). This apparently immodest and even overly ambitious thesis should be understood not as self-glorification of the intellectual or an advertisement for the science of the late 18th century, but as the advancement of an almost unattainable ideal. Fichte believes that the pursuit of science makes people better, and only the best of people can develop true science. Let us remember that at that time science had not yet come to the centre of public attention. The French Revolution was underway and executed a number of renown scientists, but soon it would be in dire need of them. The industrial revolution was beginning, and it required advanced technology, but it was yet to be understood that there were scientific achievements that would give an impetus to its development. Universities legitimized by the papal bull died, and almost no one linked their fate with science. That is why Fichte puts forward his thesis in open contradiction to the tendencies that were taking place on the surface of social life. The philosopher considers the roots and ten years after Immanuel Kant answers in his own way the sacramental question “What is the Enlightenment?”: Enlightenment is the triumph of science as it forges the new man. In this way, Fichte deciphers and clarifies Kant's answer: the coming of age of the modern human symbolizes not just the courage to live by one's own mind, not just the ordinary independence of thought, but the systematic study of science, that is, the difficult and self-sacrificing intellectual work for the benefit of society.

Michel Foucault reminds us of the polysemy of the term “humanism” and its complex relationship with the Enlightenment and modernity (Foucault, 1984). In short, if the humanistic project is only an explication of a dogmatic system of values, then it has many chances to degenerate into a tragedy of human destinies. And here we are forced to take a critical look at science and think once again about its human purpose. The humanistic advantage of science is not only and not so much in the fact that it reveals the truth to us or yields technical benefits. Science forces us to think historically and critically about ourselves and our present, encourages archaeological excavation of the past and genealogical discourse about the future, it sets boundaries and seeks means to overcome them. To be sure, scientists are not ones to believes in their own modernity with a personal understanding of the ideals of humanism. On the contrary, in the desire to be at the height of their time, they realize that the human being as an empirical subject never corresponds to the concept of humanity. Moderns are the only ones who use science in an endless search for themselves. Therefore, true humanism is not the exaltation of the human, but brings humanity to consciousness; not adaptation to conditions, but the creation of oneself anew; not a doctrine, but a constant criticism of our historical existence.

HOW HERMENEUTICS ENRICHES SCIENCE

The hermeneutics of science addresses the problem of how a philosopher, a humanitarian, or a social scientist in general can act as a mediator in communication with other scientists and with public agents. The main idea of this approach is to return to science all the richness of social, cultural, and intellectual life, in which science is *de facto* immersed. It is to revive all the excessive socio-cultural content from which modern science is trying to mostly dissociate itself; to remind the public and scientists about means of understanding science at its true value as a global social and ideological problem, like a gift that no one is able to reject.

In this context, there would be a philosophical and historical naivety to uncritically accept Thomas Kuhn's concept of "normal science," especially a view of contemporary science with its "polyparadigmatic" nature in its theoretical, experimental, instrumental, disciplinary, infrastructural, social dimensions, and what Karl Popper referred to as its "permanent revolutions" (Kuhn, 1963; Worral, 1995). And if this is so, then the constant change of meaning and sense, the process of interpretation accompanies the personal development of scientists even within the same generation and within scientific communities. In particular, scientists become more sensitive towards epistemic and moral controversies, towards understanding each other, theoretical and empirical novelties and besides all, to the impact of science on society and *vice versa.*

TWO TRENDS IN THE METHODOLOGY OF BIOLOGICAL SYSTEMATICS

In the following I will limit myself to the analysis of a peculiar kind of scientific meaning provided by the systematic ordering of natural diversity, that is by the search for a proper typology, for classification and taxonomy in biology.

My hypothesis runs as follows: the systematic (typological, classificatory, taxonomic) interpretation of a certain set of entities as an object of scientific research is a fundamental condition for any particular conceptualization. According to a holistic understanding, a top-down movement is the starting point of theorizing and not the result of creating a particular conceptual construction. Classification is a presupposition for conceptualization not *vice versa*.

Yet the question of what exactly ensures 1cognitive integrity – perception, imaginative thinking, or language – remains open and needs further research. The psychology of perception provides experimental arguments in favor of wholeness, while formal logic appeals to a construction from elements of the conceptual system („elementarism“). Both contain ontological and methodological presuppositions that determine their interpretations of the same empirical phenomena. This sphere of pre-understanding may be well a subject matter of hermeneutical study.

I carry out the testing of this hypothesis in the form of a case-study dispute in the field of biological systematics, namely that between typological evolutionary systematics[3] and the methodology of cladism.[4] Here two trends confront each other, which in philosophical terms can be designated as intuitionistic and logical-methodological ones, respectively.

EVOLUTIONARY HOLISM

In evolutionary systematics, priority is given to a holistic interpretation based on typology, natural phylogenetic classification, and the notion of the species as an element of biological reality. Basic to evolutionary systematics is a individual concept with its features of affording artificial classification as well as unambiguous analytical rigor, computer modelling, and the concept of taxon as an element of classification.

Hermeneutically conceptualized, the relationship between concept and classification reminds of the traditional hermeneutical circle of meaning and understanding. In turn, holism and elementarism might be presented as two types of ontological vision with different theoretical horizons.

The main task of systematics is to order natural diversity, to make it understandable, to give it meaning. The dominant tradition in biological systematics draws on ideas coming from Carl Linnaeus and Charles Darwin about biological reality and methods of its ordering. This is an evolutionary theory, including the modern synthetic theory of evolution. I propose that its philosophical interpretation consists in reconstructing the horizon of pre-understanding, namely the ontologies that underlie both evolutionary systematics and cladistic classification. The basic controversy rests in the concept of kinship and its applicability to higher taxa: kinship is to be interpreted either as an instrumental or an essential criterion of classification.

Thus, the main ontological category within the framework of modern evolutionary thinking is that of the species which is considered as an individual by its status (Hull, 1976). Here, the „individual“ certainly does not refer to a single flower, shrew or oyster, but a population of organisms united by a species, having special characteristics of nutrition, reproduction, genetic commonality, etc.

The unit of evolution is considered to be a species, and the main evolutionary events are the appearance and disappearance of species. A species presents the genuine “natural kind,” and the higher taxa demonstrate a gradual descendance of this naturality. From this point of view, all higher taxa and subspecies are conventional, artificial kinds, or classes of phenomena. In relation to them, such terms as “origin,” “extinction,” or “divergence of features” presuppose metaphorical application, without implying an ontological content proper. Evolution proceeds, so to speak, from the bottom up, from species to

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[3] To mention only few its main representatives: George Gaylord Simpson (1961), who coined the term “synthetic theory of evolution” in 1949, Thomas Cavalier-Smith and, in Russia, Armen Takhtajan.

[4] The father-figure of cladism is Willi Hennig (Hennig, 1966), among its current representatives in Russia are Anatoly Shatalkin and Igor Pavlinov (Shatalkin, 1991).

higher taxa. If a species is divided into several species, then the term "genus" enters the game. If in the course of evolution, a species as a lower taxon precedes a higher one, then in classification time it is *vice versa*. And the fact that a taxon of a higher rank is by definition higher is a "retrospective artifact" that owes to the concept of monophyly (birth from a common ancestor). Here, the artificial nature of the classification manifests itself here (Pozdnyakov, 1996). Accordingly, any evolutionary systematics of phylogenetic relations that uses the terms "kinship," "ancestor," and "descendant" will be correct only in relation to species as real biological individuals (populations).

CLADISTIC ELEMENTARISM

Contrary to evolutionism, a species in cladistics has the status of a class or a set-theoretic construct (Shatalkin, 1983), and this leads to the use of these terms as if they are devoid of ontological foundations: kinship is nothing more than similarity.

Let us recall that cladistics is a trend in biological systematics which develops the ideas of the German biologist Willi Hennig and relies in its more modern version on the falsificationism of K Popper (Shatalkin, 1991; Lovtrup, 1979). Cladistics designs a chain between three concepts, namely 1) semogenesis (the creation of meaning), 2) phylogeny (understanding of similarities and differences between species), and 3) classification – then postulating a kind of isomorphism between them.

One may require here a terminological and substantive explanation regarding the key taxonomic terms of cladistics, denoting similarity and kinship. So, the condition of a proper taxonomic grouping (a clade) is dubbed „monophyly" and has to meet the following criteria:

a) the grouping contains its own most recent common ancestor (or more precisely an ancestral population), i.e., excludes non-descendants of that common ancestor;

b) the grouping contains all the descendants of that common ancestor, without exception.

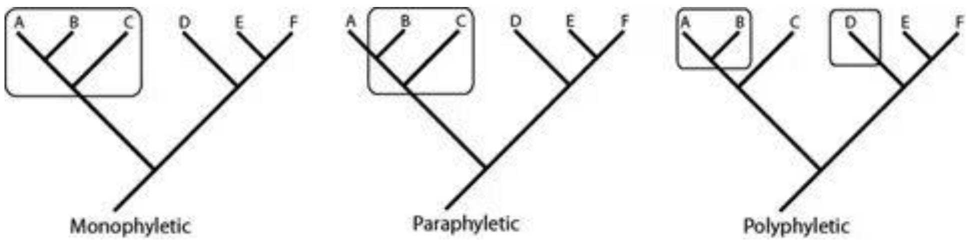

Fig. 1. Taxonomic grouping.

Monophyly should be evidentially interpreted as an unobservable hypothetical taxonomic phenomenon. Empirical evidence for the presence of monophyly draws on the conclusion about the relationship of three taxa – two sister species that arose as a result of the separation of the third line of ancestral species.

This relationship is called „synapomorphy," which denotes the kinship of two species. If a trait exists in two organisms and is present in their last common ancestor, it may indicate the presence of a clade. „Clade" is a key term for cladism, referring to the relationship of all groups within a cluster to one common ancestral group. A set of clades forms a cladogram – a family tree of the origin of organisms. The initial hypothesis about the presence of a clade, that is, the origin of the group from a common ancestral line, can be justified by morphological, genetic, and other data, which allows it to obtain the status of a stable taxon.

HOW CLASSIFICATIONS LIE: RODENTS AND LAGOMORPHS

So let a monophyletic group (taxon) be a group (of organisms), to which descent from one group of the same taxonomic rank is attributed. However, the gradual accumulation of morphological, paleontological, ecological, and other data on individual groups of organisms makes it necessary to divide them into independent ones. A typical case is the story of the order of rodents (squirrels, dormice, mice, rats, and many others), which in contrast to the latter included lagomorphs (rabbits, hares, and pikas as a suborder.

Later, the similarity of lagomorphs with rodents was declared external, and they were separated into independent orders of different origins (Gidley, 1912). The situation is complicated. In 1855, Johann Friedrich von Brandt (1802–1879) coined the now widely used term 'Lagomorpha' for this group, albeit in a subordinate rank among rodents (along with Sciuromorpha, Myomorpha, and Hystricomorpha). Brandt was a German-Russian biologist-naturalist who in 1831 emigrated to Russia and was the appointed director of the Zoological Museum of the St. Petersburg Academy of Sciences.

Moreover, although he explicitly referred to lagomorphs as a suborder (Subordo IV. Lagomorphi seu Lagomorpha'), Brandt began his discussion of these groups with the words “Ordo Leporinus...,” emphasizing their sharp difference from rodents, based on the presence of four upper incisors in lagomorphs.

Thus, while it can be argued that Brandt was the first to propose an ordinal status for lagomorphs, it was not accepted until 1912 when James William Gidley officially called for an ordinal rank for lagomorphs (Smith et al., 2018, 4–5). However, in terms of cladistics, rodents and lagomorphs are sister taxa, and both constitute a monophyletic group known today as dormouse (Smith et al., 2018, 8).

The investigations of the German-Russian biologist Brand were ignored for 50 years. This may be seen as a form of “epistemic injustice” (Fricker, ??). While it would appear quite natural that after Charles Darwin the authority of the British biological community played a privileged role in the 19th century, biological systematics reveals value- and social ladenness.

In a similar way, until recently, falcons and owls were combined into one order of birds of prey, when in fact they are two genetically different groups of birds. As soon as the polyphyletic nature of this taxon was revealed, it was divided into the orders of Falconiformes and Owls.

As we can see, the main goal of cladistics, in contrast to evolutionary taxonomy, is to reconstruct taxa in such a way that they exactly correspond in form to clades. However, it has not been possible to present the entire biological classification in the form of a cladogram, that is, to substantiate the isomorphism of semogenesis, phylogeny, and cladogram for all taxa. In fact, the precision and rigor of the formal cladistic interpretation contradicts empirical interpretations in biology, which constantly deal with the incompleteness and inconsistency of any taxon. If so, the epistemological and ontological status of taxa is fictional: they are wrong rules of reading the biological diversity similar to mathematical formulae which can be far ahead of or essentially deviate from the empirical practice of science.

CONCLUSION

I will conclude in saying that the most balanced scientific biological interpretation would result from a combination of both methodologies, although cladism is now the global mainstream in the context of the digitalization of biology.

Arguably, however, the holistic interpretation of biological diversity is preferable, although in philosophy and science the dispute between holism and elementarism is unresolvable and represents an eternal clash of interpretations (Kasavin, 2024). I suppose that there are disciplinary structures in the particular scientific community, which essentially determine decisively the theory choice, and these are linked to questions of historical dominance, temporary conservatism and authority, epistemic injustice, science wars and scientific revolutions, pseudo-science, ethical controversies (Kasavin, 2021). Since there is interpretive flexibility, the dominant interpretation or biological self-reflexion is always competitive, historically and socially laden. As Hans-Georg Gadamer puts it, “to be historically means that knowledge of oneself can never be complete” (Gadamer, 1975, p. 301-302).

REFERENCES

Dilthey, W. (1966). *Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte* [Introduction to the Humanities: An Attempt at a Foundation for the Study of Society and History]. Geubner Collection.

Fichte, J. G. (1864). *The Vocation of the Scholar* (W. Smith, Trans.) John Chapman.

Foucault, M. (1984). What is Enlightenment? In *The Foucault Reader* (pp. 32–50). Pantheon Books.

Gadamer, H.-G. (1975). *Truth and Method.* Continuum.

Gidley, J. W. (1912). The Lagomorphs an Independent Order. *Science, 36*(922), 285–286. https://doi.org/10.1126/science.36.922.285

Hennig, W. (1966). *Phylogenetic Systematics* (D. Davis & R. Zangerl, Trans.). University of Illinois Press.

Hull, D. L. (1976). Are Species Really Individuals. *Systematic Zoology*, *25*, 174–191. https://doi.org/10.2307/2412744

Kasavin, I. T. (2021). Socialnaya kritika kak nauchnaya dobrodetel: k postroeniyu vneshnego etosa nauki [Social Criticism as a Scientific Virtue: Towards the Construction of an External Ethos of Science]. *Zifrovoj uchenyj: laboratoriya filosofa, 4*(2), 73-82. https://doi.org/10.32326/2618-9267-2021-4-2-73-82

Kasavin, I. T. (2023). *A Social Philosophy of Science. An Introduction.* Nomos.

Kasavin, I. T. (2024). Taxonomies between Realism and Relativism. *Filosofsii zhurnal*, *4*, 164-172. https://doi.org/10.21146/2072-0726-2024-17-4-164-172

Lovtrup, S. (1979). The Evolutionary Species – Fact or Fiction. *Systematic Zoology*, *28*(3), 386–392.

Numbers, R. L. (2006). *The Creationists: From Scientific Creationism to Intelligent Design.* Massachusetts: Harvard University Press.

Nordmann, A. (2008). Getting the Causal Story Right: Hermeneutic Moments in Nancy Cartwright’s Philosophy of Science. In S. Hartmann, C. Hoefer & L. Bovens (Eds.), *Nancy Cartwright’s Philosophy of Science* (pp. 369-388). Routledge. https://doi.org/10.4324/9780203895467

Pozdnyakov, A. A. (1996). The Foundation of Cladistics: a Critical Study. *Zhurnal obshchej biologii*, *57*(1), 91–103.

Shatalkin, A. I. (1983). On the Issue of Taxonomic Species. *Zhurnal obshchej biologii*, *44*(2), 172–186.

Shatalkin, A. I. (1991). Cladistics and Evolutionary Systematics: Points of Divergence. *Zhurnal obshchej biologii*, *52*(4), 584–597.

Simpson, G. G. (1961). *Principles of Animal Taxonomy*. Columbia University Press.

Smith, A., Johnston, C. H., Alves, P. C., & Hackländer, K. (Eds.) (2018). *Lagomorphs. Pikas, Rabbits, and Hares of the World.* Johns Hopkins University Press.

Worrall, J. (1995). ‘Revolution in Permanence’: Popper on Theory-Change in Science. *Royal Institute of Philosophy Supplement*, *39*, 75-102. https://doi.org/10.1017/S1358246100005440

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Research article

Scientific Representation – Metaphor's Terrain

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Abstract
Scientific maxims are often used to describe common behaviors without any pretense of a common cause. The maxim 'nature abhors a vacuum' can be used to describe the distribution of molecules in a vessel or the migrations of birds. These maxims can often be replaced with other expressions ('Brownian motion', 'flocking behavior') which can give better explanations when needed. In some cases, however, two seemingly disparate phenomena may have no better terms to account for them than provisional expressions. Perhaps this is because the phenomena in question are not as distant as they seem, or perhaps it is down to the fraught relationship between words and things. In the study of cooperation in biology, a great deal of research has been devoted to symbiotic relationships between plants and mycorrhizae fungi. The term used for how plants and fungi get together is 'recognition.' We would be inclined to say that this jargon is a pretty distant metaphor and should better rest on the more familiar biological maxim of 'lock and key' as analogy. I will forcefully argue that this inclination is wrong. I will also tentatively propose that the context of symbiosis has things to teach us about communication and metaphor, and maybe even ethics.

Keywords: Scientific representation; Theory of metaphor; Chemical recognition; Models; Ethics of communication; Biological cooperation

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Научная статья

Метафора и ее ландшафт в описании научного объекта

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Аннотация

Научные максимы часто используются для описания природных объектов без попытки объяснить общую причину, лежащую в основе их поведения. Например, максима «природа не терпит пустоты» может быть использована для описания распределения молекул в сосуде или миграции птиц. Эти максимы при необходимости часто можно заменить другими терминами (“броуновское движение”, “стадное поведение”), которые могут лучше объяснить явления, хотя имеют более ограниченное применение. С другой стороны, в некоторых случаях есть описания двух, казалось бы, несопоставимых феноменов, где нет лучших терминов, чем эвристические выражения. Возможно, это происходит потому, что рассматриваемые феномены на самом деле имеют скрытую причинную связь, или, возможно, из-за давно известных сложных отношений между языком и описываемыми явлениями. При изучении сотрудничества в биологии большое количество исследований было посвящено симбиотическим отношениям между растениями и микоризными грибами. Для описания взаимодействия растений и грибов используется термин “распознавание”. Обычно нам представляется, что такие термины – это метафора, весьма далекая от описываемых явлений, и ее следует заменить аналогом – более привычной биологической максимой “замок и ключ”. Мы же решительно докажем, что такое представление ошибочно, и также предположим, что феномен симбиоза может открыть новые аспекты таких явлений, как коммуникация, метафора, а возможно, даже этика.

Ключевые слова: Научное представление, Теория метафоры, Химическое распознавание; Модели; Этика коммуникации; Биологическое сотрудничество

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FAITHFUL REPRESENTATION

Arguably the best thing the Information Age has done for the philosophy of science is to give it a pass from the burdens of realism. Even heuristic models, such as Karl Popper's, were meant to flourish before a realistic background. When you can say that a scientific law is not a 'general representation of reality' but a 'transfer of information from one system to another' you think you are making progress. This requires shifting what we mean by representation. Science no longer engages in a pale, mathetic, reflection of the real but a transfer, or processing, from one medium to another. These terms: 'transfer', 'processing', 'medium' are used as if they were directly descriptive of a hermeneutical process and not themselves figures of speech; that is a supposition that we should not leave uncontested.

One path forward was contested by Gabriele Contessa (2007) when he distinguished between what he called 'denotation' and 'epistemic modeling.' In his example, the logotype of the London Underground denotes the London Underground and no more. But the map of the London Underground gives us a model by which we may make valid inferences about the referent (Contessa, 2007, p. 52). The map is engaging us in an act of 'surrogate reasoning' (after Sowyer, 1991) where the map is a vehicle that gets us to a target, which is the referent. We reason through the map toward the Underground. Now surrogate reasoning must exhibit a great deal of variety in use. A recipe is a surrogate for the procedure of baking a cake, as is the formula for turning iron into steel; but the formula for the cosmological constant or Maxwell's third theorem is a different kind of surrogate, though all of these use symbols, orders of operation, and require a behavior of matching terms and elements.

Other surrogates are much less tidy parents of reason. Contessa distinguishes between types of 'faithful representations.' A new Underground map is a faithful representation, an underground map from the 1930s is not. He says:

> In general, a vehicle is a *completely faithful representation* of a target if and only if the vehicle is an epistemic representation of the target and all of the valid inferences from the vehicle to the target are sound. It is a *partially faithful representation* of a target if and only if the vehicle is an epistemic representation of the target and some of the valid inferences from the vehicle to the target are sound. It is a *completely unfaithful epistemic* representation of a target if and only if the vehicle is an epistemic representation of the target and none of the valid inferences from the vehicle to the target are sound. A vehicle *misrepresents* (some aspects of) a target if the vehicle is an epistemic representation of the target and some of the valid inferences from the vehicle to the target are not sound. […] Unlike epistemic representation, faithful epistemic representation is a matter of degree. A representation can be more or less faithful to its target. The same vehicle can be a faithful representation of some aspects of the target and misrepresent other aspects. This seems to be the case with the old London Underground map. (Contessa, 2007, pp. 54–55)

Clearly Contessa has some knowledge of the London Underground. Someone who does not know what a London or an Underground is might find themselves vexed trying to determine the faithfulness of any of their, or his, inferences. But we should not let ignorance be a guide. Take a person who is maximally knowledgeable about the London Underground, a London Underground historian. For this scholar, researching the state of the Underground in 1935, what invalid inferences might be drawn from the Underground map of 2025? Indeed, some of the inferences Contessa drew about the map in his article of 2007 would not be valid now. Let Contessa counter that the historian is not using the map in the way it was intended at any time. But then imagine a historical novelist who wants to give an accurate impression of how their protagonist would move between stations in the 1930s. In this case, the map could be used very much like it was in 2007. The presence of new stations and the absence of old ones are not the only weaknesses in Contessa’s arguments. Clearly, his and most of the other scholarship related to scientific representation is not comparing information and information, but information and an ideal object: his Underground is clearly platonic. Maps do not need to be particularly verisimilar, in fact some maps (even Underground maps) are deliberately abstract to draw out the right features, or merely to show you it is a map. These features are isolated for a particular purpose: to identify the function of the representation and to lead you through the steps. Perhaps the term ‘surrogate reasoning’ is itself too mathetic, suggesting an externalization of internal mental ideas.

There is much about the whole debate surrounding scientific representation that could use a good whipping from the first part of Ludwig Wittgenstein’s *Philosophical Investigations* (1953/1991), or any responsible theory of intention. If you use the logo of the Underground to find the Underground does the logo not have some epistemic purpose? Is a signifier the surrogate for the signified? If the most likely version of representation in the brain is correct, and all references are made up of neural networks, then any kind of denotation is a map and all references are surrogates. Maps clearly also have something to do with their practices around their use and not just their references.

As Anguel Stefanov says, much of the question during this period of the debate was about what ‘modeling’ means (2012, pp. 70–72). I would add that there is a parallel problem with what ‘vehicle’ means. This vehicle is a commuter vehicle, like the London Underground, that gets you from one place and back. But communication is a much more complex process. After Wittgenstein, it might be better to see modeling as an activity, a game, gesture, or ritual rather than a means of transport. There is a particular intention behind gestures and sets of rules. One can imagine these rules being learned as one learns to use maps, or being explained by things such as keys and legends. The boxes around the keys and legends on maps are like the boundaries of the ritual ground or the rope around the proscenium of the stage. One of the rules is an intuitive understanding of the levels of verisimilitude in a map. In order to be successful in communication the map must put across the intended grain of verisimilitude. The target is here the intention and not a presumed ideal object in reality. Again, ‘vehicles’, ‘targets’ like ‘transfer’, ‘processing’, ‘medium’ are terms that we presume have a direct connotation with little concern as to their own filial surrogacy or faithfulness. A set of dance steps may be part of a ritual intended to bring rain, or an elaborate code to open up a lock, or a praise to an exalted personage. Once we commit to connecting practices instead of levels of verisimilitude, there are other, stranger correspondences afoot.

SCHOLIA

There is little to distinguish the kinds of reference we have in science from the hustle and bustle of semantics in everyday language. Consider the types of phrases common in medical diagnoses: ‘*rubor, calor, dolor, tumor*’ – ‘redness, heat, pain, swelling’ is the classical definition of inflammation. The rhyme is an *aide-mémoire*. The diverse set of symptoms which some types of poisoning present has led to: ‘Red as a beet, mad as a hatter, dry as a bone, hot as a hare, and full as a flask.’[5] These phrases help define a range of systems that might present themselves with other signs, or do not completely present themselves. The definition is a guidepost from the tradition. ‘*Rubor, calor…*’ goes all the way back to the physician Celsus, a contemporary of Christ. There are still other devices that use *logical* shorthand instead of poetics. They are not meant to account for things as they are or as they actually happen, but they account for certain *blendings* that allow us to observe something else, especially when we want to determine a cause.[6] These are heuristic constructs but, unlike the literal verses from medical school, they are not meant to then lead to a more true etiological definition. They are provisional, but they are also permanent. The proper name for these phrases is ‘*axiomes vulgares*’ but I would prefer the less precious term ‘scholion.’[7]

Consider the phrase ‘nature abhors a vacuum.’ It accounts for nearly everything you might observe with respect to the dynamics of objects, but as a principle it does not explain anything. It is a story used to account for why something comes in the place of something else. There are many reasons why natural movement occurs – diffusion of gases, movement of electrons, foraging behavior of animals, the ‘path of least resistance’ (also a scholion). ‘Nature abhors a vacuum’ can account for any one of these, and others, too. There could be a distance opened up between a traveler and a crowd and a platform on the Underground. She walks because nature abhors a vacuum. A cavity opens up in the body because of a resected appendix. Nature’s concupiscence filled the void with fluid. Who would say these things have the same cause, that the scale of the secretion of lymph is the same as the push in a narrative plot and the Brownian motion of particles? One could just as easily say: ‘Things move around.’ The scholion lets us end up with an explanation as a kind of myth. The myth makes life easier.

Sets of blended myths do not pose a problem so long as the scientist and philosopher know that they are provisional, heuristic way-stations from which we will

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[5] Anticholinergic toxicity is the poisoning in question.

[6] Causal blending in both science and conventional language is examined in Fauconnier and Turner (2003, pp. 93–95). They consider the phrase ‘my tax bill gets bigger every year!’ A tax bill is not one thing that grows like an artichoke. We speak of many iterations of things in the same class over time as if they were one to illustrate their sequential change. Blending, compression, conflation are used to express a kind of causality – like the much-memed “March of Progress” (1965) illustration of an ape walking down a timeline to become a man.

[7] In the sense of a “condensed maxim or ancillary explanation” rather than in the narrow sense of “gloss or marginal note” (see Dickey, 2007, pp. 13–14).

move on. They are much more of a problem for those who see no need to ask why or have no sense of conceptual hygiene. Many disciplines, especially in the so-called ‘narrative sciences’ (geology, biology, economics), use scholia with seemingly no second thought. This may be because it is too provisionally difficult to give up the myth or because language makes it difficult to come up with concise expressions. These conflations thus make you think you are talking about one layer of relations – words and things – but you have slipped, blended, several layers of identity, causality, and representation together. And since this has to do with causes, this slippage operates like a kind of magic.

At their best in rhyme and reason, scholia are no more than verbal tools. No doctor thinks that ‘*rubor*, *calor*…’ gives a faithful or comprehensive description to make an adequate contribution to pathology. Still these might be considered forms of surrogate reasoning and models of a kind.

‘THE CAREER OF METAPHOR’

What might be needed is to parodize the terminology of Contessa, Stefanov, and others. The ‘denotative’ function follows the regular semantic pattern for natural language with all its highways and byways, and the ‘surrogate’ or ‘constituitive’ function involves the game, ritual, or gesture that uses a model. Among a number of the features to this art is the convention of learning and using levels of abstraction (see Floridi, 2008) or varying grains of intentional verisimilitude.

Interestingly, a test of validity can come when we try to switch these two elements, or practices – target and base, comparison and comparandum – with respect to the same object of investigation. In regard to a gesture, in naming a formula we have almost the same schematic processes as we would with naming a ritual or a dance: ‘F = *d*p/*d*t’ > ‘Newton’s Second Law of Motion’ and ‘slow-slow-fast’ > ‘the fox trot.’ But move from name to map and find that denotation demands the extraction of a script. If you choose the fox-trot, you have a number of plausible instances (not just tokens): ‘slow-slow-fast,’ a video, a series of numbered photographs, a step diagram. Any of these could reasonably be a valid representation. The same goes for Newton’s Second Law. One of the ways to learn physics well is to solve these equations for yourself, go through all the steps. Now if you choose ‘Nature abhors a vacuum,’ you can give what might be the most fine-grained account – the formula for Brownian motion – but that does not cover anything like the whole scope of uses for this phrase in science (see Fodor, 1974). Unlike the diagnostic maxims mentioned above, many of the doctors of biology, economics, or urban planning that might use such a phrase would not be able to do much with the formula for Brownian motion, nor any of the models offered by their colleagues from other sciences. And this is not because ‘Nature abhors…’ is a more general term than an expression of Brownian motion; it is simply a less effective denotation that cannot be converted into a functional model. Unlike a good general classification, such a denotative marker might be a good shorthand term, nothing more. Functionality should trump verisimilitude, but the rules of mapping must pertain to the function.

As we extract ‘models’ from ‘denotations’ in Contessa’s fashion, we see that analogies begin to look more and more like metaphors. For the last several decades, cognitively aware theories of metaphor have moved away from a convention of metaphor as a 'deviation' from lexical reference. Around the time of Contessa (2007), Brian Bowdle and Dedre Gentner proposed a theory of the 'career of metaphor' based on experimentation (2005). Metaphor's career marks where broad and loose semantic mappings of association become gradually compressed into more fixed categories as the metaphor becomes more conventionalized. Bowdle and Gentner, note that neat Venn diagrams of matching and non-matching features do not allow for the expansion of a metaphor beyond already evident analogies that make them tidily, but uninformatively, conventional: "… metaphoric mappings often involve the projection of new forms of information from the base to the target" (2005, p. 194). A superimposition of homologous terms is not a functional metaphor. Psychology and cognitive science have demonstrated that metaphor's mappings are not just additional to expression, but essential to it.[8] What most determines the comparison seems to be the invocation of the terms themselves and not their relations. For example, even Bowdle and Gentner's examples set limits too firm for the multi-directionality of metaphorical terms. Taking the metaphor 'dew is a veil,' they note that certain common features to both target [= veil] and base [= dew] of a metaphor will necessarily enter into its interpretation:

> For example, both dew and veils are inanimate, and both are silent, but neither of these common properties seems relevant to the meaning of 'Dew is a veil.' A second criticism concerns the issue of asymmetry: Although the order in which two items are compared should not influence their degree of property overlap, metaphors often cannot be reversed or change their meaning […]. For example, whereas 'Dew is a veil' is a meaningful figurative statement, 'A veil is dew' seems nonsensical. (Bowdle and Gentner, 2005, p. 194)

Yet one could easily conjure a few mediocre lines of poetry to vitiate both these points:

> Silent,
> The veil is dew
> Dappling blossoming brides.

If metaphor has a career, its path must have some twists and turns of fortune. It seems the theorists of metaphor could use a lesson from the Surrealists, just as the philosophers of scientific representation could use one from Wittgenstein. The direction of what on juxtaposes does not matter, but it does matter which features one isolates by invoking them. In his highly neglected "Remarks on Frazer" Wittgenstein (2020) notes that one could take a set of myths and come up with any functional explanation for what they represent so long as the explanation harkens to some basic human element (Wittgenstein, 2020, § 11–13, pp, 38–42). The same could apply to the target and base of

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[8]See Lakoff and Johnson, 2003, Ortony et al., 1985, Cooke and Bartha, 1992. As Iain McGilchrist notes, metaphorically, "The explicit is not more fully real than the implicit. It is merely the limit case of the implicit, with much of its vital meaning sheared off: narrowed down and 'finalized.' The literal is not more real than the metaphorical: it is merely the limit case of the metaphorical, in which the wealth of meaning is collapsed into a 1:1 correspondence for a useful, temporary, purpose" (McGilchrist, 2021, p. 17).

metaphors. Pull an element from the semantic field of one and the situation of juxtaposition itself will call forth associations with the other. As Bowdle and Gentner suggest above, metaphor relies on the disjunction of the partners in the juxtaposition (“new forms of information…”) as much as – even more than – the similarity. Psycholinguists would say that exposure to disparate stimuli primes the functional networks that link commonalities while keeping disjunctive elements active or potentially active. A poem, or a ritual, or a work of theatre forms new contexts out of juxtapositions. The pairing works because the terms engage in asymmetrically disjunctive and dynamic engagement. The point is less to identify or denote and more to keep two points of conjuncture active: to keep them in play. This requires a sense of boundary, scale, and interaction. The selection of elements in a metaphor must both preserve the distance in the terms, accent it, and propose an improbable relation. A novel metaphor is then like a map.

REACTION AND ‘LOCK AND KEY’

Any analogy or metaphor may thus serve as a potential model for surrogate reasoning. The extent and the manner in which they matheticize, graph, or map to one another stands between semantics, poetics, and the study of scientific representation. The function of analogies differs: some are better for explaining what you do, some are old heuristic habits that die hard. Some of them can be replaced by a more accurate set of expressions at the loss of generality. Among the principal terms in the lexicon of chemistry and biology is the word ‘reaction.' From the 16th century, it had the sense in physics and nascent chemistry of an interaction between two bodies as indicated by the Latin ‘r*e-agere’* (‘to do back’) designating the event of an interaction: sulphuric acid ‘reacts with’ silver to produce silver sulphate and oxygen gas. Over the course of the 19th century, reactions gained a highly formal language of representation, one that has only recently been enhanced by the advent of digital visual representation. These together would make the finest examples of surrogate reasoning. Moving out to biology, chemical reactions can be very highly conditioned and complex. Organisms need to do particular things at particular times to maintain the fundamental relationship between their insides and outsides (Mitchell, 1957). A photoreceptor in the eye or an insulin receptor in the liver is ready and waiting to respond to a necessary stimulus. The stimulus ‘triggers’ the response. Since receptors and stimuli are in such a tight relationship, a phrase is used to describe the triggering: ‘lock and key.’ As an analogy, it is almost ubiquitous. A lock is no good for anything but a key and a key for a lock and the expression of one matched to the other is a statement of unidirectional relationship and causality, quite like ‘nature abhors…’. In some cases, the analogy works: DNA and RNA, ATP and ADP. Here, lock and key ‘captures the model-relation well’.[9] But in many other references – no less ubiquitous – it is not. The purpose of insulin is not just to trigger receptors in the liver, but to support the metabolism of glucose in general. That very fact explains why insulin needs to operate the trigger. It is a key, but also a door.

[9] Considering reverse transcription, ‘button and hole’ might be even more apt.

In his recent book, *How Life Works*, Philip Ball takes this lock and key scholion to task. He notes that the 1960s and 70s established a mechanistic conception of biochemistry, but that the malleable nature of proteins and their often unstructured reactions make a travesty of such a unidirectional model (Ball, 2023, pp. 158–159). Indeed, the computer-generated, three-dimensional crystal diagrams of proteins show how incredibly more complex their surfaces are than the classical, unidirectional chemical diagrams. And many proteins cannot be crystalized. The same can be said for the idea of 'chemical messengers.' Real messengers, on bicycles or on horses, deliver a message and then go home. Most of the time, however, biological messengers go to the recipient and eat the message and themselves, or deliver the message by being devoured by the recipient. The resulting reduction in the quantity of messengers results in the reduction of the message and the reaction of its recipient. And yet, 'locks and keys' as well as 'messengers' remain simultaneously persistent and ineffective representations.

I would venture that this predicament holds for two reasons: generalizing causes and semanticizing agents. Note that the processes taking place in 'lock and key' and 'messenger-message-recipient' are separate from their results. You put a key into a lock to get into something or somewhere – to get into elsewhere. The message likewise is a separate entity from the messenger and recipient. Perhaps we are proposing a model of words and things where this model of communication does not belong. We are inclined to separate the vehicles that convey the process from the process itself, as we would separate signifiers from the signified. Biology is more efficient. It does not require mediation. One would even prefer to say that biology is *prior*, it subsists in a world where mediation by naming processes is a useless application. Like Contessa's Underground, there are platonic ideas in these analogies that are hiding in plain sight.

This is especially the case when we digitize biological processes. Metaphors like 'genes are a language,' 'the brain is a computer' rely on the practice of marking biological processes with signs, manipulating the signs, and then imposing the nature of the representation and manipulation back onto the transcribed system. The same might be said for the phrase 'chemical recognition.' After all, 'recognize' is an even more anthropomorphic metaphor than language. Ball (2023) notes that chemical recognition is an essential term for the for the initiation of a process p. 154). Surely there could be something better.

RECOGNITION

If chemical reactions can give us the best examples of surrogate reasoning, the semantics of 'chemical recognition' should take mapping to a new level. I have not been able to arrive at a good historical account for how 'chemical recognition' emerges as a term in the biological literature and must hope that these reflections receive some more rigorous attention. The rub is contrasting 'reaction' with 'recognition' and a little play with these terms might tease some of the differences out. One would not consider, for example, the event of mixing silver with sulphuric acid as a moment of recognition between silver and acid. This sounds a bit like Dido recognizing the fire. Recognition seems to require two independent entities who meet for an interaction and are in some way preserved, if altered, with the result. Chemical recognition means using a set of chemical reactions for each of the parties to do something else. Why then would we not speak of 'lock and key'? Ball's discussion suggests that 'recognition' refers to a set of interactions that take place at varied times and in varied ways. The two entities meet and the act of recognition is built into their interaction. For it to have significance, recognition must by itself be a separate process from the interaction and there must be some reason why it must stand apart. This reason can be that recognition triggers an internal process to one or either of the partners that is not exhausted in the course of the reaction but, so to speak, continues on. Thus the need to preserve individual integrity persists because the static and dynamic position of the relationship needs to be preserved. While there is a 'recognize' or 'do not recognize' binary to recognition, the 'accept' or 'deny' model of lock and key does not account for these other features.

With a little help from broader phenomenological reflection that would limit processes to behaviors, and by throwing the risk of anthropomorphism to the winds – since it already has been – recognition might require the following features:

a. Excitability = anxiety

To be recognized, something must be recognizable. This does not mean that it has to have a sensory capacity or a memory of prior acquaintances. The senses require that we cast a wide net and catch what we expect and what we do not expect, memory requires multiple stimuli and reinforcement. Recognition requires only the capacity to recognize. This capacity, however, is not static, like the capacity of a beaker. It is an expenditure of energy to await the stimulus of another. If A were always able to determine the advent of B, then there would be no need for recognition. The fact that A must invest energy in B, and B in A, to be able to recognize, means that each must invest energy in the recognition of the other or only to await the advent of the other. There is perhaps no better term than 'anxiety' for this dependency on what is awaited. If we are going to use 'recognition,' why not 'anxiety'? Perhaps such a term captures the importance of the investiture of energy expended in the synthesis of the membranes and appendages needed for recognition.

b. Preen and Peruse

The meeting then must be an event where each element can display its recognizable features. One of the more significant developments in recent genetic research has shown that the folding of proteins has an immense effect on how they are processed and synthesized. A great deal of the chemical environment around DNA and RNA is geared to manipulate the surfaces exposed to possible reactions. To recognize something you have to see enough of its features, to be recognized you have to display enough of these features. Unlike lock and key, chemical recognition requires a kind of choreography, like the dances of the 16th century that required participants to display the frills and attributes of their rank. If someone's crest were bunched up in their sleeves, how were you to know who they are? Each partner thus must preen before the other and then peruse the other so that recognition take place.

c. Engagement-non-engagement

If recognition *is* to take place, the previous elements must lead to this binary judgement of recognize or not-recognize. Here the lock and key model might be best applied: the pins and ridges are aligned and a third process can take place, the result of the recognition. However this resultant event can only take place on the basis of the prior two features, and it is only a part and not the whole of the process.

All these terms can be applied to the career of metaphor and, by extension, to some forms of representation. Every expression that requires surrogate reasoning must be designed around a particular level of abstraction that will make the expression functional. If we conceive of a formula as a type of expression that is meant to be solved, then the design of formulas builds in a set of anxieties about the quantities that are to be plugged into variables. Perhaps every element of a mappable representation involves an affordance of anxiety and expectancy about its application. As they are applied again and again, these affordances hone the elements of an expression to their most functional state.

This analysis has finally reversed the received epistemology of representation as mimetic. One first must recognize something by its cursory marks, then know it before you can make of it a faithful copy. Yet if recognition and representation are part of parallel processes, mimesis is already in the gestures of preen and peruse. One is reminded of the Indo-European root ‘mī’ from which the words mime, imitate, and measure come. If we limit ourselves to mapping behaviors and gestures, the range of correspondences becomes far more unfamiliar.

DECORATION = RECOGNITION

Anxiety, preening, perusing, engagement – these terms are far better suited to courtiers or birds than cell walls and long-chained molecules. Replacing verisimilitude with function and gesture, one cannot say that as models they are worse than ‘trigger’ or ‘unlock.’ Their surrogacy suits to the extent that what might be called a metaphor is also a model. If the test of suitability is functional and technical, there might be little real difference between the two.

Let us take an example which can either give the lie to the mapping or confirm it. In fact, like the career of metaphor, this example shall be not just an exercise in gesturing but a contribution to surrogate reasoning and modeling as hermeneutics.

As one might remember from school biology, many plants engage in symbiotic relationships with fungi. A broad class of fungi grow into the root systems of plants. The plants provide the fungi sugars while the fungi chemically bind nutrients to be digested by the plants. Explanations of symbiosis are full of teleological reasoning: Some fungi do good for plants and others infect them with disease. Defensive mechanisms must be in place for the right roots to match up with the right fungus. There is thus an affordance between the energy expended to make a more complex lock and key and the benefit of the relationship. The keys and locks of mycorrhizae fungi and plant structures have evolved into very complex and, by any stretch of the imagination, *baroque* structures of communication that ask, with 17 th century French diplomatic prolixity: ‘Am I right for you? Are you right for me?’ The technical term for these complex appendages on plants and fungi is ‘decoration’ and the process seems always to be called ‘recognition’ (e.g., Besserer et al., 2006, Rasmussen et al., 2016). The fungus and the molecules around the root structures recognize one another by decoration.

There seems to be nothing that distinguishes this recognition from that of a face, or a password – the assembly of correspondences which lead to an (electro-)chemical reaction, new physical information. And versions of this communication of surfaces can be seen throughout biological, including neurological, activity. Marching up from the roots to the tree to Newton sitting under the tree, there may be no observable difference between the baroque recognition of these symbionts and the far simpler recognition that takes place on the part of neurotransmitters. That is their capacity, and recognition their activity.

The teleology of symbiosis brings out a sense of agency in each of the partners, yet it only makes explicit processes which must be present in any recognition. Perhaps it is only the risk of impostors that makes prolixity absolutely necessary, but certainly decoration is a surface for ‘preening and perusing.’ Nevertheless, it is clearly also a product of the intensity of the exchange. Because mycorrhizae do not just engage with their symbionts from the outside but propagate deep into the hosting plant’s root systems, we can say that the amount of decoration is directly proportional to the level of risk – you need more complex locks because you have more to lose. ‘Complex enough’ is a necessarily fuzzy category: complexity itself is an emergent phenomenon (one cannot move from simple to complex in one step), and there is not a certain level of complexity that would suit all possible keys and thwart all possible thieves: complexity in recognition is imbued with the anxiety of the possibility of recognition desired or undesired.

Beyond, or before, teleology, we might take a lesson from metaphor’s career. As Bowdle and Gentner noted, metaphor functions just as much on the dissimilarity between its partners as on their similarity (Bowdle and Gentner, 2005, pp. 194). Whereas Jacobson and Groupe μ’s work in the 1960s concentrated on metaphor as a deviation from lexical denotation, more recent theories of metaphor concentrate on overlapping fields of meaning which prompt one another in various mappings. The notion of lexical meaning is then like Contessa’s platonic London Underground and deviation always tethered to it. In contrast, mental mapping, or network theory, might lead one to the sense that metaphor operates as a field of references with only weighted differences between target and base. This disregards the event of metaphor: that new metaphors are coined with a particular intention that can rearrange relations between target and base regardless of prior positions and proximities.

Eliminating the boundary between target and base in metaphor violates the rules of the exchange. The principles of game theory can fruitfully account for symbiotic behavior (see Nowak, 2006), but game-theoretical models cannot be built if there is no distinction between players. Perhaps the more empirical explanation of both mycorrhizae and metaphor is that the more overlap there is between the partners the more differences need to be maintained. Referring once again to the sphere of games and dances, the elaborate sleeves and fans of French or Japanese court culture were incorporated into gestures, theatre, and dance. The greater the inventory of possible gestures, the more need there was to have ordered structures to display them. The greater the number of points of contact, the more involved the preening and perusing.

Perhaps no less effective a metaphor for metaphor than the *career* of metaphor – a temporal illustration – is the *terrain* of metaphor – a spatial one. Poets vary the terrain of their targets and bases by massaging them with disjunctions. Semantic and imagistic expectancies (what in Indian aesthetics is called *akankshá*) are toyed with and manipulated in novel ways as the reader joins and disjoins elements of the verse. The distinction between the partners is maintained by rules of engagement: rhyme, metre, parallelism. Poets such as Keats or Bashō have strict patterns of juxtaposition, others such as Celan or e.e.cummings incorporate syntax and etymology. One can think of the metaphors in René Magritte's canvases: disjunctions are brought into greater relief by clean brushstrokes and mundane shadings of familiar objects in disjunctive settings. Similarities are toyed with along with deviations: preen and peruse. Like a map, metaphor shows a destination (dew→veil), and it presents the byways to that destination in its terms and conventions.

DIFFERENCE AND ETHICS

One might be persuaded that the real basis of interaction between partners is communication and that any theory of communication would naturally carry more surrogate weight than that of cooperation. One could say that lock and key communicate in order to open the door. But this is not always the case. The target and base of metaphorical relations are not communications with one another, but together form a communicative act. We have determined that a fundamental feature of chemical recognition over chemical messengers is that each of the partners maintain their integrity throughout the exchange. This is not always the case with chemical communication.

What does seem to be essential in cooperation, metaphor, and representation is a sense of the need for surface and difference. These two seem to be interdependent: the membrane around the cell, the root wall, the semantic field of a term or image, all depend on the surface marking the boundaries between partners as being the source of both anxiety and also preening/perusal. The duality is not just that of one boundary and membrane – *x* and ~*x* – but two boundaries and thus two internal states.

Our example of symbiotic decoration thus is an aid to understanding how meaning-making structures might work without denotation or signification, before what Iain McGilchrist calls the 'limit case' of the literal (McGilchrist, 2021, p. 17). But while we might easily dispense with denotation in favor of functional surrogacy, the position of intention is far more ambiguous. If it is helpful to anthropomorphize fungi with anxiety, there is no reason they should be denied their little intentions. The whole phenomenon of symbiosis relies on (at least) two partners, if we want to avoid applying teleology from outside the system, we have to conceive that the relations between partners carry their own intentions without some utilitarian intervention.

Perhaps it is at this point where the ultimate anthropomorphism needs to be indulged. While the study of biological cooperation has often tried to avoid any whiff of fundamental ethics, philosophers and theologians have not been able to resist (Almenberg et al., 2013). The more sensitive of them do not only attempt to prove the universality of morals, but also to investigate what these purely insentient agents might reveal about our own ethical systems. The reverse might also be true. The need for two internal states and two decorated boundaries is a better analogy to an 'I/thou' relation than a relation of ‘inside/outside’ or ‘*x*/~*x*.’ The position of radical ethics, given its classic expression by Emmanuel Levinas, is that the idea of the other is total, as he says, “an infinity” (Levinas, 1969, p. 51). This means that no presumptions of overarching purposes or internal states are valid. Boundaries, then, become everything, preening and perusing is duty. Indeed, adjusting for Jacques Derrida and Gilles Deleuze’s critique of Levinas, we might see a decorative membrane, a baroque fold, as a better model of recognition than the face.

Finding an inherent ethical element in metaphor – in the maintenance of semantic integrity along with a terrain of informative disjunctions – might be of some use to aesthetics. The moral connotations of metaphor have always been read on the basis of intentions, often following a kind of sterile absolutism, and not on the fundamental models upon which associations are built. Such an approach might also help to relieve neuroethics of its deontological prejudices (see Trimble in Kopeikin and Nesteruk, 2024).

But is this all not a case of functional conflation? Is not the intention of surrogate reasoning to create precise, functional models that will allow us to propagate tokens or fulfill functional tasks? What precision can we gain from a morally structured fungus? After all, is the Deleuzian rhizome not intended to bring healthy, decentralized disorder? A hermeneutic in a theory of representation based not on verisimilitude but on functionality cannot help but arrive at sets of relations which jar, cajole, or dismay. Three simple arguments, one weaker and two stronger, support the relevance of such musings.

First the weaker: while symbiosis emerged as a concept early on in theories of evolution, it has always been seen more as an anomaly in comparison with competition and adaptation. Recent decades have shown, both through observation and theoretical modeling, that cooperation may be just as important to biology as competition. In fact, symbiosis with microorganisms is thought to have given plants the leg-up they needed to go from the sea to the land some 460 million years ago. This nicer kind of social Darwinism does not come from some marginal corner of biology, but from a set of dynamic principles foundational to life.

The first stronger point is that this theory of representation accounts for a number of similarly-structured processes that can resolve complex questions in a variety of ways and at several levels of abstraction. In order to use a cooperative theory of biology for the understanding of metaphor we do not have to argue that metaphor is more ‘natural’ than lexical denotation. In applications of metaphors to natural language, texts, or works of art, we only have to see how well the model works when it comes to giving a defensible explanation. Nor do we have to argue that there is a natural connection between neural networks and the career of metaphor, or participants in a game-theoretical model. But the virtue of applying such models is that they, like metaphors themselves, allow us to see structural connections where they might not have been seen before. Rather than inevitably taking a semiotic convention and applying it to biology, taking a biological phenomenon and applying it to semiotic conventions may bring out new models of functional significance. To the extent that life (at a certain scale) is always *better* than death, theories of living things are also inherently given a pass from the fact/value distinction. Using ethical principles to understand physical systems seems as anachronous as hanging a bull for goring a man. However, such principles used in these terms are not normative but derive directly and intuitively from the natural behavior of two mutually distinctive agents primed for contact.

The second strong point seems paradoxical. The foundation for cooperation in biology is mutual benefit and this presumes either that each of the agents is aware of the benefit or that structures have emerged through natural selection to give advantage to those traits which lead to mutual benefit. Symbiosis carries its own purpose. As is well known, biology has a fraught relationship to teleology (see Hull, 1982), and biologists tend to qualify their teleological statements as heuristic scholia. But the sets of relations we have examined do not require an external purpose. Anxiety, preen and peruse, engagement can all be attributed to observable behaviors in the partners themselves. These are relations of surfaces and gestures and not of purposes and aims. At some level it is unhelpful to understand the relations between types of bean plants and types of smuts without mutual benefit: we may not be able to see some of the evolved features of these relations; and at some levels it is unhelpful to argue that a poet had no reason to fashion a particular metaphor. But in gestures and surfaces we have models for understanding relations at basic and empirical levels which we do not have when we must presume a cause or end.

There is clearly a virtue to positing models of scientific representation that do not give preference to the semiotic but that find application in the structures and behaviors around representational activity. That such disparate sets of applications arise could speak to the model's robustness and not its weakness.

RICHER TERMS = BETTER MODELS

Funny things happen when you relieve scientific models of the call to be mirrors of nature. After all, no model or map is ever considered to be equal to the territory it maps. Behaviors, practices, and traditions behind acts of scientific representation expose gestures, anticipation, and display. Some models persist for functional purposes: short-hand communication, diagnostics, but they do not serve to build functional models upon which new mappings can be built. Unexpectedly, metaphors do offer models that sometimes exhibit much more functionally applicable behavior. Comparable mapping gestures apply but, like formulas, they require a certain relationship between individual elements (or terms) to maintain the usefulness of the map.

This suggests that the gestures or games around mapping require a set of relations between partners, which further implies a radically ethical relation. Indeed, whereas the forms of cooperation we see in biology might be analogously applied to ethics as an example or lesson, a theory of representation which relies on mapping behaviors arrives at a set of necessary processes that pertain to recognition: the preparation, expectation, and invested energy of a meeting (anxiety), the full and extended presentation of recognizable features (preening and perusing), and the confirmation or denial of relations (engagement).

That metaphor, cooperation, molecular recognition, and scientific representation might exhibit comparable sets of gestures likely has to do with the interaction between independent entities with varied internal states and complex patterns of interaction, as game and graphing theories would attest. A certain asymmetry in their states gives them their dynamism. The cooperative model takes these patterns to be a surface over which the process of recognition takes place. This means that the richer the surface, the more involved the set of relations, while ethics tells us these surfaces must only give a limited account of the internal states of each of the partners in the exchange. At a time when vast quantities of data can be milled by patently amoral actors, setting ethics at the fundament might reveal even richer surfaces.

Gross anthropomorphism or not, applying a theory of molecular communication to metaphor offers no more of a challenge to empiricism than saying that cells *are designed* to release hormones. A disciplined examination of the behavior of recognition without presuppositions as to its purpose implies that such relations have functional commonalities. Perhaps we use anthropomorphic terms for these relations because there are simply no better ones.

REFERENCES

Almenberg, J., Brooke, J. H., Clayton, P., Curtis, H. D., Dixon, T., Dreber, A., Fisher, J. C., Hall, N., Hauert, C., Hauser, M. D., Jackson, T. P., Johnson, D. D. P., Kosslyn, S. M., Lee, M., Lohmann, F., Porter, J., Pruss, A., Rota, M., & Schloss, J. P. (2013). *Evolution, Games, and God: The Principle of Cooperation*. (M. A. Nowak and S. Coakley, Eds.). Harvard University Press. https://doi.org/10.2307/j.ctvjnrscp

Ball, P. (2023). *How Life Works: A User's Guide to the New Biology*. University of Chicago Press.

Besserer, A., Puech-Pagès, V., Kiefer, P., Gomez-Roldan, V., Jauneau, A., Roy, S., Portais, J.-C., Roux, C., Bécard, G., & Séjalon-Delmas, N. (2006). Strigolactones Stimulate Arbuscular Mycorrhizal Fungi by Activating Mitochondria. *PLoS Biology*, *4*(7), e226. https://doi.org/10.1371/journal.pbio.0040226

Bowdle, B. F., & Gentner, D. (2005). The Career of Metaphor. *Psychological Review*, *112*(1), 193–216. https://doi.org/10.1037/0033-295X.112.1.193

Cooke, N. J., & Bartha, M. C. (1992). An Empirical Investigation of Psychological Metaphor. *Metaphor & Symbolic Activity*, *7*(3–4), 215–35. https://doi.org/10.1207/s15327868ms0703&4_7

Contessa, G. (2007). Scientific Representation, Interpretation, and Surrogative Reasoning. *Philosophy of Science*, *74*(1), 48–68. https://doi.org/10.1086/519478

Dickey, E. (2007). *Ancient Greek Scholarship: A Guide to Finding, Reading, and Understanding Scholia, Commentaries, Lexica, and Grammatical Treatises, from Their Beginnings to the Byzantine Period*. Oxford University Press.

Fauconnier, G. & Turner, M. (2003). *The Way We Think: Conceptual Blending and the Mind's Hidden Complexities*. Basic Books.

Floridi, L. (2008). The Method of Levels of Abstraction. *Minds and Machines*, *18*(3), 303–329. https://doi.org/10.1007/s11023-008-9113-7

Fodor, J. A. (1974). Special Sciences (Or: The Disunity of Science as a Working Hypothesis). *Synthese*, *28*(2), 97–115. https://doi.org/10.1007/BF00485230

Hull, D. L. (1982). Philosophy and Biology. In *La Philosophie Contemporaine / Contemporary Philosophy: Chroniques Nouvelles / A New Survey* (G. Fløistad, Ed.) (pp. 281–316). Springer Netherlands. https://doi.org/10.1007/978-94-010-9940-0_11

Kopeikin, K., & Nesteruk, A. V. (Eds.). (2024). *Consciousness and Matter: Mind, Brain, and Cosmos in the Dialogue Between Science and Theology*. Pickwick Publications.

Lakoff, G., & Johnson, M. (2003). *Metaphors We Live By*. University of Chicago Press.

Levinas, E. (1969). *Totality and Infinity: An Essay on Exteriority*. (A. Lingis, Trans.). Duquesne University Press.

McGilchrist, I. (2021). *The Matter with Things: Our Brains, Our Delusions and the Unmaking of the World*. Perspectiva Press.

Mitchell, P. (1957). The Origin of Life and the Formation and Organizing Functions of Natural Membranes. In A. I. Oparin, A. G. Pasynski, A. E. Braunstein, T. E. Pavlovskaya (Eds.), *Proceedings of the First International Symposium on the Origin of Life on the Earth* (pp. 229–234). Academy of Sciences.

Nowak, M. A. (2006). *Evolutionary Dynamics: Exploring the Equations of Life*. Belknap Press: An Imprint of Harvard University Press.

Ortony, A., Vondruska, R. J., Foss, M. A. & Jones, L. E. (1985). Salience, Similes, and the Asymmetry of Similarity. *Journal of Memory and Language*, *24*(5), 569–94. https://doi.org/10.1016/0749-596X(85)90047-6.

Rasmussen, S. R., Füchtbauer, W., Novero, M., Volpe, V., Malkov, N., Genre, A., Bonfante, P., Stougaard, J. & Radutoiu, S. (2016). Intraradical Colonization by Arbuscular Mycorrhizal Fungi Triggers Induction of a Lipochitooligosaccharide Receptor. *Scientific Reports*, *6*(1), 29733. https://doi.org/10.1038/srep29733

Stefanov, A. (2012). Theoretical Models as Representations. *Journal for General Philosophy of Science / Zeitschrift Für Allgemeine Wissenschaftstheorie*, *43*(1), 67–76. https://doi.org/10.1007/s10838-012-9178-0

Swoyer, C. (1991). Structural Representation and Surrogative Reasoning. *Synthese*, *87*(3), 449–508. https://doi.org/10.1007/BF00499820

Wittgenstein, L. (1991). *Philosophical Investigations: The German Text, with a Revised English Translation 50th Anniversary Commemorative Edition* G. E. M. Anscombe, and E. Anscombe, Eds.) [3rd ed.], (. Wiley-Blackwell. (Original work published 1953)

Wittgenstein, L. (2020). *The Mythology in Our Language: Remarks on Frazer's Golden Bough*. (G. da Col and S. Palmié, Eds.). HAU.

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Research article

Hermeneutics and Science: Taxonomies, Interpretations, Subjectivity

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Abstract

This article is written in response to a position that sees hermeneutics as not just a method of interpreting texts, but rather as a fundamental cognitive strategy that opposes the scientific type of knowledge. This approach implicitly includes the ideas of the essence of science, its language and subject as consequences. In short, we can call the position which opposes hermeneutic and scientific approaches the "hermeneutic-scientific divide (HSD)" view. The purpose of this research is to examine critically the ideas of the representatives of the HSD approach to science as an area of experimentally verified interpretations, the clarity of scientific language, which eliminates the need for interpretation, and the neutrality of cognitive subjects, where scientists act as intermediaries transmitting knowledge without changing their personalities. We also aim to show that hermeneutical approaches remain an integral part of science despite science's desire for objectivity. As an argument, we propose to consider examples from the history of science. These include the dispute between Camillo Golgi and Santiago Ramón y Cajal about the structure of the nervous system; Charles Walcott's research in taxonomy and paleontology; and the debate about the phoneme between the Leningrad and Moscow schools of phonology. These cases show that even when using the same methods and data, interpretations of results can vary depending on the assumptions of researchers. They also demonstrate the impossibility of neutral, unbiased language in science. The article concludes that scientific language cannot completely avoid interpretation, despite its efforts to be objective and formal. Scientific texts always contain hidden contexts related to the historical, social and methodological conditions of their creation, as well as the value aspects of scientific work and the implicit knowledge of the author, along with his subjective assessments. Hermeneutic analysis is also essential for the formation of a scientific identity and the transmission of scientific traditions. Interpretation remains a key element in scientific knowledge, while science appears as a dynamic process in which objective data and subjective interpretations go hand in hand to form new knowledge.

Keywords: Hermeneutics; Science communication; Taxonomies; Classifications; The subject of science; Experiment; Interpretation

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Научная статья

Герменевтика и наука: Таксономии, интерпретации, субъективность

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Аннотация
Настоящая статья написана как ответ на позицию, которая рассматривает герменевтику не просто как метод интерпретации текстов, но как фундаментальную познавательную стратегию, противопоставленную научному типу познания. Этот подход имплицитно включает в себя представления о сущности науки, ее языке и предмете в качестве следствий. Эту позицию, противопоставляющую герменевтику и науку мы можем для краткости условно обозначить как “hermeneutics-science divide (HSD)”. Цель нашего исследования – критически рассмотреть тезисы представителей HSD о сущности науки, ее языке и субъекте. Цель нашего исследования – критически рассмотреть тезисы автора о науке как области экспериментально проверяемых интерпретаций, ясности научного языка, исключающего необходимость герменевтики, и нейтральности субъектов познания, где ученые выступают как посредники, транслирующие знания без изменения своей личности, и показать, что герменевтические подходы остаются неотъемлемой частью научного процесса, несмотря на стремление науки к объективности. В качестве аргументации мы предлагаем рассмотреть примеры из истории науки, такие как спор между Камилло Гольджи и Сантьяго Рамон-и-Кахалем о структуре нервной системы, исследования Чарльза Уолкотта в области таксономий и палеонтологии, а также дискуссия о фонеме между Ленинградской и Московской фонологическими школами. Эти кейсы демонстрируют, что даже при использовании одних и тех же методов и экспериментальных данных интерпретация результатов может существенно различаться в зависимости от теоретических предпосылок исследователей, а также показывают невозможность нейтрального, не нагруженного теоретически и этически, научного языка. Основные выводы статьи заключаются в том, что научный язык, несмотря на стремление к формализации и объективности, не может полностью исключить интерпретацию. Научные тексты всегда содержат скрытые контексты, связанные с историческими, социальными и методологическими условиями их создания, ценностными аспектами научной работы, неявным знанием автора и просто его субъективными оценками. Также герменевтический анализ необходим для формирования научной идентичности и передачи научных традиций. Таким образом, интерпретация остается ключевым элементом научного познания, а наука предстает как динамичный процесс, в котором “объективные” данные и субъективные интерпретации всегда идут рука об руку, формируя новое знание.

Ключевые слова: Герменевтика; Научная коммуникация; Язык науки; Таксономии; Классификации; Субъект науки; Эксперимент; Интерпретация

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INTRODUCTION

The article proposes to consider some theses regarding the language of science and the role of hermeneutics within it. There is a view that describes hermeneutics not only as a set of techniques related to the interpretation and comprehension of texts, but also as a fundamental cognitive approach - a hermeneutic type of cognition, contrasting with a scientific approach to knowledge. For simplicity, we can refer to this view that contrasts hermeneutics with science as the "hermeneutics-science divide" (HSD). Both types of knowledge seek to find "truth" in their own way. Hermeneutical knowledge sees truth as the product of human understanding through interpretation, while scientific knowledge presupposes acquiring relevant knowledge about its subject. "Interpretation functions through the creation of meaning through common action and theory, and language contributes an abstract element, while common action adds a cultural or practical element" (Heelan, 1998, p. 287). Scientific knowledge is never definitive. Hermeneutics and science as cognitive concepts imply certain images of the world. By interpreting these images, we can draw conclusions about what the author means when using the language of science, how scientific subjects appear, and how to define the boundaries of scientific knowledge. I would like to discuss three propositions with the author: all are related to understanding "the language of science" and its features. The first proposition is related to experimental interpretation; the second concerns the use of real language without hermeneutical interpretation; and the third introduces the impact of scientific texts on readers.

1. Science as a field of experimentally verifiable interpretations. From the HSD perspective, science is defined as a field where the meaning and correctness of the interpretation of a theory or data can be verified experimentally. If there are different interpretations of the phenomenon, they should lead to empirical consequences that can be confirmed or refuted. Hermeneutic issues in science are temporary and eliminated in the experimental verification process. The experiment reveals the properties of the world and clarifies scientific concepts, forming the language of science.

2. Clarity of Scientific Language. Scientific language is designed to ensure that scientists can understand each other without the need for additional interpretation or explanation. The terms and symbols used in scientific communication are formalized and agreed upon within the scientific community, reducing ambiguity and subjectivity in communication. This eliminates the need for scientists to ask questions such as "what did you mean when you used this word in this context?" (Nordmann, 2025, p. 5). Science supports the idea that a shared language automatically ensures mutual comprehension without interpretation.

3. "Neutral" subjects of cognition. Unlike fiction or philosophical literature, where the author plays an active role in the process of meaning formation, a scientific text aims to eliminate subjectivity. The author of a scientific text acts more as a mediator, transmitting knowledge, while the reader assimilates information and remains unchanged in this process:

> Philosophical hermeneutics considers the making of meaning as a process that involves how we understand ourselves and a notion of who we are. <...> There is none of this in science, supposedly. Scientists may come up with a changed understanding of nature but they are not looking to change themselves, to develop their character or grow as a person. They are what they always are: Impersonal knowing subjects who experiment and observe, perhaps interpret, and draw conclusions. (Nordmann, 2025, p. 5-6)

These three aspects are closely interconnected. The language of science defines the boundaries of scientific discourse and shapes the boundaries of science itself. It is intrinsically linked to the process of cognition, involving both the speaker and the listener. The central question is whether it is possible to imagine a language that eliminates the need for hermeneutics.

EXPERIMENTS AND INTERPRETATIONS

At the ceremony of awarding the Nobel Prize in Physiology or Medicine in 1906, a rare event happened: the two prize winners were not colleagues, but irreconcilable opponents. Camillo Golgi and Santiago Ramon y Cajal, both awarded the highest scientific award, stood on opposite sides of one of the main disputes in the history of neuroscience. They had one thing in common – the silver staining method, which allowed them to see the structure of the nervous system with unprecedented detail for that time. But the paradox was that using the same experimental method these two scientists, whose qualifications we simply cannot doubt, saw completely different things. Golgi, a staunch proponent of the reticular theory, saw that the nervous system is a single, continuous network. Cajal, in turn, came to the conclusion that it consists of individual cells – neurons that transmit signals to each other through specialized contacts.

This case shows that, in science, an experiment does not put an end to disputes about interpretations once and for all. Golgi and Cajal worked with the same data – visual images produced by silver staining – but their theories were not limited to “testable empirical consequences.” They interpreted what they saw through the lens of their beliefs. Golgi, who supported the concept of the integrity of the nervous system, saw confirmation of the reticular theory. Cajal saw neurons, as he was looking for cellular units. The experiment didn't determine a result that needs to be interpreted once and forever, because science isn't just a series of confirming or refuting experiments and accumulating data. It's also a field where objective knowledge forms through a clash of interpretations and human beliefs.

Another example of the dependence of scientific data on interpretation is the case of fossil classification. The research of Charles Walcott, who discovered many previously unknown fossils in the Burgess Shale at the beginning of the 20th century, demonstrates how crucial the use of accurate hermeneutical procedures in taxonomy is. Based on the linear view of evolution that prevailed during his time, from simple to complex, Walcott interpreted fossils through the lens of existing taxa. He attempted to fit new forms into existing classes, turning them into precursors of modern worms, jellyfish, and other animals. Instead of allowing for the possibility of modifying the model itself, Walcott adjusted his data to fit the existing theoretical framework. Thus, he flattened his findings and failed to appreciate their true significance. An analysis of the collection conducted by a group of British scientists half a century later revealed that the fossils discovered by Walcott possessed unique anatomical features and belonged to taxa unrelated to modern classes (Bryson, 2019, pp. 217-219).

This case shows that taxonomies are not just a neutral reflection of natural diversity, but complex constructions that depend on the researcher's interpretative framework. Without a proper hermeneutic procedure aimed at identifying the meanings hidden behind original classifications, scientific knowledge may be distorted. Data does not exist in a vacuum; it is always embedded in cultural and theoretical contexts that determine its perception and use.

In this sense, taxonomy requires not only empirical observation, but also significant work with data – work that takes into account the limitations of current paradigms and allows for their possible revision. The correct hermeneutic approach in taxonomy is not merely a methodology, but a crucial tool for adequately representing biological diversity and creating accurate scientific models.

Thus, the idea that science is a field where the meaning and correctness of interpretations can be experimentally verified is too narrow. Science also includes interpretations that cannot be resolved experimentally. Firstly, empirical data that resolves uncertainty depends on interpretation itself. Secondly, unambiguity does not occur when we conduct experiments: different scientists interpret results differently. These ideas call into question the possibility of absolutely neutral scientific language and show that hermeneutic aspects are an integral part of scientific knowledge. While the processes of interpretation and re-interpretation occur in science, they remain alive; they cannot be excluded from the process of knowledge, they are an essential part of science itself.

THE LANGUAGE OF SCIENCE AND ITS SUBJECTIVITY

Let's turn to the question of scientific language, which does not require interpretation according to the HSD representatives. A scientific text is not just a set of protocol sentences that directly correspond to reality. It also contains a "collapsed" image of scientific reality, including both facts and methods, theories, values, and science practices, as well as the implicit knowledge and cognitive features of the author. A scientific text can be interpreted and deciphered, requiring hermeneutical analysis since it is more than just a collection of protocol sentences correlated with reality but also includes contexts of utterance, such as conditions of production, historical contingency, and the author's affiliation with a particular paradigm. The contexts can vary greatly: science is not monolithic or unified, but rather a complex variety of discourses and methods. This multiplicity creates the need for interpretation from historical, ethical, social, and methodological perspectives.

The normative ideal of science implies, of course, the complete elimination of the external social context and the internal subjective principles from the scientific text. This ideal is difficult to achieve, but it is important to strive for it. There is always a last frontier

– the human language that is used to write scientific articles. “Probably the first powerful multiplier of the image of science was language, which emerged as a fundamental instance at the very heart of the work of scientists and broke Western modern science into paradigms based on theoretical constructions” (Varkhotov, et al., 2018, p. 6).

Note that the reason for subjectivity, which in turn presupposes the inevitability of interpretation, is the cognitive features of the language of science: it is both the metaphorical nature of language (including scientific) and the conceptual nature of scientific terms. Terms are not words with unambiguous dictionary meanings but concepts with many linguistic features rooted in reality. This includes the need to present and interpret visual data as the result of an experiment as well as implicit knowledge embedded in scientific texts. This means it is impossible to create an "objective" language of science completely separated from humans and as a result does not require hermeneutics.

To be more specific, Nordmann's (2025) thesis connects to this idea by suggesting that they do not, however, interpret each other in what they say and write – they do not usually ask, 'what did you mean when you used this word in this context?' hardly corresponds to reality. There have been persistent disputes over the definition of key terms in scientific discussion. A notable example is the debate between the Leningrad and Moscow phonology schools about what should be considered a phoneme. This disagreement has led to a need to pay close attention to the concept of phoneme being used and the criteria behind its definition when reading texts on the subject, as it affects the classification of phonemes and the overall number in the Russian language.

The question of the meaning of the phoneme is central to phonological theory, but it is impossible to give an unambiguous definition of the phonemes: the interpretation of this term varies significantly within the frameworks of the two leading schools of Russian phonology – the Moscow and Leningrad phonological schools.

According to the Moscow Phonological School, a phoneme is an abstract sound type that combines all possible sound realizations (allophones) depending on the phonetic environment. A phoneme does not have a specific sound but manifests itself through its variations in speech. The main criterion for phonemic affiliation is the role of a sound within a morpheme. If different sounds are interchangeable within the same morpheme, then they are considered to be allophones of the same phoneme. This leads to a more compact taxonomy, as many phonetic differences are seen as positional variants of a single phoneme. For example, the soft sounds /g', k', x'/ (/г’, к’, х’/) are not considered separate phonemes, and the sound /y/ (/ы/) is considered variant of the phoneme /i/ (/и/). The Moscow School thus identifies 39 phonemes based on this approach.

The Leningrad School of Phonology defines phonemes based on their perceptual properties and functional roles in language. A phoneme is the smallest unit of sound that can distinguish between words and their different forms. The most important criterion for defining a phoneme is not only its position in the structure of a word, but also the awareness of native speakers that it makes a difference.

In this regard, the Leningrad school recognizes a larger number of phonemes, including /g', k', x', y/ ((/г’, к’, х’, ы/)), which have an independent status and lead to a classification with 41 phonemes.

The debate surrounding the meaning of key terms, such as “phoneme,” illustrates that scientific language cannot be entirely objective or free from interpretation. The differences between the Moscow and Leningrad schools of phonology highlight that even within the same discipline and language, the understanding of terms can vary dramatically based on theoretical assumptions and methodological approaches. This shows that scientific terms are not neutral or unambiguous; they must be interpreted according to the context, paradigm, and cognitive perspectives of researchers. Therefore, hermeneutic analysis is an essential part of the scientific process, even in fields that strive for maximum formalization and objectivity.

SCIENTIFIC TEXTS AS A SPACE FOR THE FORMATION OF THE SUBJECT

Our position is that a scientist is not just an observer who captures objective reality and transmits his ideas, but an active participant in scientific communication. This opinion is opposed to the HSD approach. For example, Nordmann, referring to Hertz, describes the ideal image of a scientist who is not involved in “mere empty discussions about words” as a figure “left alone with nature.” Perhaps such an ideal was suitable for 19th-century science, but in modern science, a scientist (especially a natural scientist) is inevitably embedded in a network of scientific interactions. Their research is discussed outside the scientific community, inside science at conferences, reviewed by experts, commented on by editors of scientific journals, and then becomes public, subject to interpretation, discussion, and even controversy. All this represents the necessary stages of unified scientific communication. This multi-stage communication does not interfere with scientists, but it is a fundamental and most important part of the formation of scientific knowledge. Communication in science is not just the transfer of knowledge, but also the process of its collective creation, interpretation, and refinement. Scientific texts play a key role in this process, influencing not only readers' knowledge, but their ethical attitudes, worldviews, and scientific identities.

Alfred Nordmann on the controversy speaks about the immutability of the subject of scientific research (both for the author and for the reader): “As opposed to the knowing subjects of scientific research, the subjects of hermeneutic exegesis do not remain unchanged in their course of inquiry” (Nordmann, 2025, p. 4). It is difficult to agree with this statement, since in scientific texts the idea of scientific ethos, the procedure for carrying out scientific experiments, and a set of values and rules for a scientist's behavior are laid down. Reading scientific texts conveys not only methodological knowledge but also shapes a scientist's personality, determining his attitude towards science, colleagues, and society.

> Scientific vocation acts as a gift in this context (divine or initiated by a teacher), and this gift requires reciprocal gifts – a scientist must impart knowledge to his students and those around him. His obligations are limited to broadcasting not only knowledge but also the gift of vocation, which is the basis for selfless relationships within science and the involvement of newcomers into it. (Kasavin, 2020, p. 252)

It is interpretation, conscious or subconscious, that makes it possible to identify the “second layer” of a scientific text containing ideas about values, virtues, and ethical norms in the scientific community. When reading a scientific text, researchers not only assimilate information, but also encounter models of scientific behavior, forms of argumentation, and styles of presentation that reflect specific ideals of science. Therefore, interpretation not only helps comprehend the content but also changes the reader, contributing to his or her formation of scientific identity and ethos.

A scientific text, therefore, is not a neutral means of transmitting knowledge. It is a space where, through interpretation, the next generation of scientists are educated, scientific traditions are consolidated, and values are transmitted that determine the perception of science and its place in society.

RESULTS

In this article, we have presented a critical analysis of the “hermeneutics-scientific divide” position in which scientific and hermeneutic forms of knowledge are contrasted. We emphasize the special role of language in scientific knowledge and the unavoidable role of interpretation in scientific research. The main findings of our study can be summarized as follows.

Using the example of the debate between Golgi and Cajal, as well as Walcott's research, we demonstrated that the experiment does not eliminate the need for interpretation. Even when using the same methods and data, scientists can arrive at different conclusions. This highlights the role of theoretical assumptions and cognitive attitudes in scientific cognition. The experiment is not the ultimate arbiter in disputes about interpretations, and scientific knowledge is shaped through a clash of diverse viewpoints.

Scientific language, despite striving for formalization and objectivity, cannot be completely free from interpretation. The example of the confrontation between Moscow and Leningrad phonological schools shows that even within the same discipline, the understanding of key terms can vary dramatically. This indicates that scientific terms are not neutral and require hermeneutical analysis to identify their meaning in specific contexts. A scientific text does not simply convey knowledge but also shapes the reader's scientific identity. Through the interpretation of scientific texts, scientists learn not only methodological knowledge but also ethical norms, values, and traditions of their scientific community. Therefore, scientific texts act as a means of educating new generations of scientists and preserving scientific traditions.

Thus, hermeneutics remains an integral part of scientific knowledge, since the interpretation of data is a key process in science. Scientific language, despite its striving for objectivity, always contains elements of subjectivity, making hermeneutical analysis a necessary tool for understanding scientific texts and constructing scientific knowledge.

REFERENCES

Bryson, B. (2019). *A short history of nearly everything*. AST.

Heelan, P. A. (1998). The scope of hermeneutics in natural science. *Studies in History and Philosophy of Science Part A*, *29*(2), 273–298. https://doi.org/10.1016/S0039-3681(98)00002-8
Kasavin, I. T. (2020). The ethical paradox of science: Between the absolute and solidarity. *Tomsk State University Journal of Philosophy, Sociology and Political Science*, *55*, 249–254. https://doi.org/10.17223/1998863X/55/25
Nordmann, A. & Bylieva, D. (2025). Hermeneutic Dimensions of Science and Technology. *Technology and Language, 6*(2), 1-20. https://doi.org/10.48417/technolang.2025.02.01
Varkhotov, T., Gavrilenko, S., Ivanov, K., & Pisarev, A. (2019). Objectivity and its history. In L. Daston & P. Galison, *Objectivity*. (pp. 5–42). NLO.

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Research article

Hermeneutic Methods in Science

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Abstract

Hermeneutic methods have ordinarily been used in humanities and social studies where theories and descriptions do not explain observable facts, but interpret actions, texts and cultures. However, there is a progressing tendency to synthesize methodological insights and research programs in practices of technoscience as presupposed by actor-network theory or program of integration for qualitative and quantitative methodology in sociological investigations. Alfred Nordmann is convinced that objective scientific knowledge cannot be a subject of exegesis and subject-related interpretations, because knowledge in science depends on conventional language and models as sense-making devices. Therefore, hermeneutics of science is a less coherent project than hermeneutics of technologies. This opinion is interesting to compare to pluralism of scientific descriptions, when alternative conceptual frameworks can be equally valid and justified. The aim of article, thus, is to explain hermeneutic practices in scientific communication and cognition by exposing theoretical and historical arguments which warrant the application of hermeneutic methods in research of nature. It states that, according to perspectivism in cognitive sciences, considering theories as construals, constructivist component in theories of mental modeling and interpretative semiotics, scientific models are necessarily subject-related. In addition, we can find historical evidences that hermeneutics of science is connected with Christian intellectual tradition, natural philosophy and modern technoscience.

Keywords: Hermeneutics of science; Philosophy of language; Semantics of terms; Models in science; Incommensurability; Classifications and semantic networks

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Научная статья

Герменевтические методы в науке

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Аннотация
Герменевтические методы, как правило, применяют в гуманитарных и социальных науках, где концепции и дескрипции не объясняют наблюдаемые факты, но интерпретируют действия, тексты и культуру. Но существует восходящая тенденция синтеза методологических инсайтов и исследовательских программ в практиках технонауки, что предполагает акторно-сетевая теория или смешанная методология количественных и качественных исследований в социологии. Альфред Нордманн считает, что объективное научное знание не является предметом экзегезиса и субъективных интерпретаций, поскольку знание зависит от конвенционального языка и моделей как интерпретирующих устройств (“sense-making devices”). Поэтому герменевтика науки - менее последовательный проект, чем герменевтика технологий. Его мнение интересно сопоставить с плюрализмом научных описаний, когда альтернативные концептуальные схемы являются равно правильными и оправданными. Цель этой статьи заключается в объяснении герменевтических практик науки и познания, которые оправдывают применение герменевтической методологии в исследовании природы. В соответствии с перспективизмом в когнитивистике, который представляет теории конструктами, конструктивистскими компонентами теорий ментального моделирования и интерпретативной семиотикой, модели необходимо относятся к субъекту. Кроме того, мы можем найти исторические свидетельства того, что герменевтика науки связана с христианской интеллектуальной традицией, философией природы и современной технонаукой.

Ключевые слова: Герменевтика науки; Философия языка; Семантика понятий; Модели в науке; Несоизмеримость; Классификации и семантические сети

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INTRODUCTION

Firstly, Alfred Nordmann argued that there is no need for hermeneutics of science, at least, in „normal“ regime of enquairy, because in normal science scholars use conventional and objective language for communication.

Secondly, scientists succeed in achieving consensus in regard to the truth of theories and content of terms in contrast to poets, literary writers, humanists, or artists, whose works are subjected to exegesis. As a result, hermeneutic interpretations play a part on the backstage of science, but philology is not a primary scientific occupation. More likely verbal disputes, or disputes concering the meanings of terms, reveal anomalies in experience of scientists.

Nordmann has mentioned three approaches to hermeneutics of science. One of them, associated with Gaston Bachelard and Thomas Kuhn, presumes that hermeneutics affords drawing boundary between science and poetry, because scientific language shows transparency, publicity, and intelligibility, whereas poetry implies unconventional usage of language, corruption and unfamiliarity of meanings, subjective interpretations of symbols by readers and authors of cultural texts. Another model for hermeneutics of science is illustrated by Heinrich Hertz’s specifications of Maxwell’s equations, conceptions of matter, and principles of mechanics. Hertz distinguished philological and philosophical modes of enquiry when “empty disagreements” of scientists and “uncertainty of meanings” can be resolved by physical tests and empirical experimentation closing the debates in a humanistic club of physics. Here hermeneutics works as a preliminary and temporary method before truly scientific treatment. And the third approach to hermeneutics of science differs from others, since it does not exclude exegesis from research practices, though its relevance is explained not by personal knowledge, perception or language skills, but work of abstract models as hermeneutic agents connecting interpretable data and interpretable theories unambiguously.

It seems to me that Nordmann prefers the last approach, a restricted view for hermeneutics of science, when the meaning of terms is discussed until models have passed the process of adaptation, calibration, tuning, and acceptance for conventional usage. Properties of things and knowledge of tendencies are exteriorized in models revealing the capacities and causal structure of natural phenomena (Nordmann, 2008, p. 375-376). In the empiricist view of Nancy Cartwright, a hermeneutic circle allows to connect abstract theories and perceptual data due to mediating function of models. Models become autonomous agents, distinct from objects as well as theories. Models, not scientists, read the world and, being impersonal readers, interpret the theories (Cartwright, 2008, p. 390).

Margaret Morrison, Mary Morgan and Cartwright explain in many details what the scientific models are. They can be descriptions of facts, diagrams, mock-ups, simulations, measures, equations, or conceptual schemes. Facts and objects are not imagined apart from models, which represent, substitute, and interpret facts and objects for enquirers. Models must properly fit the world as well as the theories of the world. Unlike models, theories are abstract, contingent, and lack concrete meaning. A set of models provides a semantic interpretation for a theory. However, the models may be more phenomenological, and others stay more theoretical. Models are part of theories if they are interpretive and may be developed like tools of representation for empirical phenomena (prototypes, classifications, statistical data, visualizations, or whatever else) (Hartmann et al., 2008; Knuuttila et al., 2025).

Following Ludwig Wittgenstein, the received view in the philosophy of science considers the world of science as the totality of facts described in empirical statements (even if propositions are only one way of representation among others): "There are clear criteria for the truth of such descriptive statements – and no hermeneutics required for thus producing a description of what is true in a world" (Nordmann, 2025). It means that truth criteria must be explicit, rational and conventional, even when it is not so (Morgan & Morrison, 1999, p. 352), and scientists do not necessarily agree on what is good science and the best theories at present. Later Wittgenstein became convinced that the structure of the world is not disclosed in language games and not supposed to be represented by symbolic isomorphisms.

There is inconsistency if we approve hermeneutics in preliminary research and reject hermeneutics for the advanced stage of investigation. Kuhn famously proposed the idea of normal scientific practice, but it is not how he understood history of science and life of communicating communities. He devoted much attention to how humans learn language, get familiar with the meaning of terms, and socialize in professional groups of scientists. From his point of view, language depends on cultural experience, both alive and variable. And science is integrated into diverse social contexts where there is no uniformity of language and the meanings of signs. Since Karl Popper and Paul Feyerabend, many philosophers have been questioning the existence of normal scientific practice. Scientific models are not universal, and this means that scientists must come up with limits of their application to the real world. According to Cartwright, models communicate some amount of descriptive and factual content conveying partial truth in relation to objects; they fit certain circumstances, but not others. Therefore, scientists produce knowledge sensitive to contexts of cognition. If so, we can regard seriously not only hermeneutics of technology but also of science, especially technoscience where research methods, fields, and practices experience hybridization. In the following chapters, I formulate philosophical and historical reasons, which might warrant the hermeneutic methods in science.

ARE MODELS SUBJECT TO INTERPRETATION?

Models as sense-making devices are quite convincing idea to me. Humans find the way to the world via cognitive labor: analyzing and comparing data, prototyping, building models of objects, fitting models to theories and one to another, theorizing sophisticated problems. That is compatible with a semantic and set-theoretic view of theories as well as a broader semiotic reading of scientific models explaining their expressive, descriptive, manipulative, explanatory, and predictive power.

Semiotics as a field of study investigates how signs acquire meaning, connect one to another and get interpretation by users in communication. It does not divide the types of discourses, whether scientific or literary tales we communicate; in sense that all of them follow the rules of structure and understanding. For Cartwright prepared and unprepared descriptions ground representative models by which theories and covering laws can be interpreted and related to observable objects and situations in the world, because theories are simulacra if taken without derivative phenomenological laws and generalizations. Unprepared descriptions bear all information gathered in relation to phenomena under research. They are made in multiple, ordinary conversational, phenomenological, experimental, or partly theoretical languages and by multiple language means from graphical to propositional. Whereas prepared descriptions are more selective and proper for building models of scientific objects.

All languages function as precategorized signifying systems, which symbols can describe a type (regularity), a token (single fact) and a tone (quality) of phenomena if to adopt Charles Peirce terminology. In cognitive semiosis, phenomena are arranged, classified, named and notified, and this is how languages provide speakers with conceptual maps, or mental models for organizing experience. In scientific language the modeling achieves a similar purpose as for perceptual data or general theories, also called grand and fundamental theories. The last ones aim to explain as many observable phenomena and known models as possible. A unifying account of modeling in cognitive processes was proposed in works concerning the conceptual structure of language by Kuhn; model-based reasoning by Hesse, Philip Johnson-Laird and Nancy Nersessian; cultural schemata theory by Roy D'Andrade; connectionist networks by Claudia Strauss and Naomi Quinn; mental modeling in collective systems by David Kronenfeld; usage-based interpretation of language and ICM in cognitive linguistics (Wassmann & Bender, 2015).

Still, it is not clear what are scientific models as autonomous agents among other representations and descriptions of objects in phenomenological, experimental, or theoretical languages (Morrison, Morgan, Cartwright), given these languages are essentially mixed (William Quine, Wilfred Sellars). Models can be justified apart from a theory and even data, as in thought experiments and with idealized models. However, models do not seem ontologically detached as a kind of third entity, standing away from other conceptualizations like terms, propositions, taxonomies, axiomatizations, or theoretic descriptions, even if simulative reasoning based on models is something more than inductive, abductive, and deductive arguments in logic (Nersessian). That's why the different models give us good means to analyze the epistemological toolbox of science.

Some examples of models in science are accounting-balance model in monetary economy theory, perfectly rational agents in decision-making social theories, the Hardy-Weinberg equilibrium, the MacArthur-Wilson and Lotka-Volterra equations in population ecology, the Price equation in evolutionary theory, or statistical models of wildland fires in environmental studies. They are compatible with the middle-range theories, which serve to represent a particular phenomenon or explain a set of empirical data in social and other branches of science. However, the models are used on lower (data models, scale models, taxonomies, classifications) and upper levels (equations, abstract models, computer simulations) in research, where they differ in functions and features (Frigg & Hartmann, 2020). In addition, phenomenology and theories have moving boundaries, and what was once a theoretical entity becomes observable like cells and molecular structures, genes, electromagnetic fields, atoms, and black holes. On the other hand, observable phenomena can be re-theorized in the subsequent thought like space, motion, force, gravity, planets or blood circles. Observable and detectable objects also differ in their epistemic reliability, the last ones depend on the theoretical descriptions and the assumptions in a greater degree. All this, however, does not prioritize phenomenological generalizations over theories and vice versa, endorsing constructive realism in relation to models. Even if theories may fail or function as approximations, in particular because they model only selected features of a targeted system and involve abstractions and idealizations according to model-based interpretations of science.

Material models and samples provide scientists with copies of objects and typical representatives of natural kinds. Material models do not reflect all features of objects, representing necessary aspects and behavior. They are used to show spatial positions, shapes, connections, and proportions of parts (globus, anatomy maps, molecular models); movements and interactions of objects (car on inclined surface, airplane kit, billiard balls model of ideal gas); particular physical and other effects (field lines of magnet, movement of spring bodies); internal and external design and landscapes (architecture models); standard representatives of a kind (material samples). The real objects can deviate from typical features of models like diseases, pathologies, and variations of norm in bodies; physical properties of atoms in isotopes; and chemical structures of matter in mixtures, alloys, and polymers.

Philosophers explain the reference of taxa in terms of similarity and essentialism, classes and universals, constructions and natural grouping. Merging of these ideas is possible because different models represent the world differently. There is no one shared opinion on how classifications correspond to the world. Analysis of biological taxa has shown that species, particularly related to peripheral isolates, hybrids, syngameons, asexual and symbiotic organisms, do not satisfy one or another criteria for biological kinds and attribution to higher classes (Stanford, 1995). First, this means that variations of species are greater than presupposed by the idea of "natural kindness." Second, any single criterion for grouping individuals (morphological, cytological, ecological, genetic, or phylogenetic criteria) should not be privileged. Third, variations of traits and criteria of grouping are responsible for pluralistic systematizations, equally valid and justified. Fourth, divisions in species and kinds depend on objective properties of individuals along with pragmatic reasons of investigators who can take into account clinical, pathognomic, epidemiological, ecological and other features of species (see, e.g., (Baron, 1996) and (Burrell et al., 2016)).

John Dupre (1981) states that taxonomic realism implies the existence of one correct classificatory system, excluding alternative models; however, species do not display uniformity. According to other opinions of philosophers, realism admits pluralism in classifications and theoretical frameworks (Philip Kitcher). No wonder that phylogenetic studies of biological species have influenced the revisions of traditional views and redistribution of units under taxonomical rubrics. What results in wide proliferation of biological theories. Phylogenetics reasonably pretends to dismiss previous classifications but does require extensions to be more analytic. Another remarkable fact is that, developing the Hubble sequence, astrophysitists have created new classifications of galaxies (Lundmark, de Vaucouleurs, Vorontsov-Velyaminov, Sandage, York, and other systems). Due to gravitational interactions, distortions and collisions, galaxies acquire irregular shapes and difference in structure, size, density, radiation and other characteristics, not strictly supposed by typologies. Astronomers have been finding the unusual types of objects like ring and dwarf galaxies, clumpy and transition galaxies, and quasar and blazar galaxies improving former taxonomical models by the addition of new criteria, types, prototypes, and divisions along with the application of automated methods of data analysis for multi-class classifications (Yeganehmehr & Ebrahimnezhad, 2025). Taxonomies become more pluralistic and less realistic in constructivist interpretations, though philosophically contested. Another illustration may be Nebula clouds, relating to many cosmological objects with diffuse structures, gaseous matter, dust, and regions of star formation. They refer to parts of space, which turn out to be irregular galaxies, galactic embedded clusters, molecular clouds of interstellar matter as Herbig-Haro objects and dark cold nebulas, luminous HII regions near hot stars or, as well, clouds around a dying stars and supernova, where physical and chemical events differ dramatically.

Finally, our main question may be asked: are scientific models detached from the authors and, as a result, not subject to interpretation? Perspectivism in cognitive sciences, treating theories as construals, constructivist ideas in theories of mental modeling and the interpretative component in semiotic models of communication do not lead to this conclusion. We know well that natural languages do not possess clarity and unambiguity. If scientific communication alters from other discourses in clarity, transparency, and tendency to conventional expressions, its capabilities and linguistic means as a condition of interpersonal communication in science deserve theoretical explanation and evaluation as a hermeneutic issue. In addition, Robert Merton thought that scientists are disposed to collaboration because of common ethos and epistemic imperatives. Jurgen Habermas saw readiness for understanding and finding consensus as a preliminary condition for rational communication among humans. We do not have *a priori* and empirical evidence that communication of scientists is perfectly rational, supportive, and cooperative. For cognitive theorists, interpersonal communication connects diverse cultural communities, and only shared experience can unify lexical meanings and create wholes from individual units. In certain social theories, consensus among scholars and conventionality of language are not a norm, but theories are costly in terms of multiple resources, and many of them are not seriously contested with a time what works for stabilization of knowledge. Michael Polanyi was convinced that understanding science and scientists requires background knowledge, salient, personal, and not explicitly expressed in formalisms and propositions. This means that knowledge is interconnected with the individual states of mind as much as the shared world (whatever it is).

These extended contexts allow us to understand philosophy of science as hermeneutics of science and technology. Philosophers ask for foundation and background of knowledge, logical soundness of reasoning, ontological presuppositions, social and cognitive biases of scientists and established theories, possible consequences of discoveries, and future prospects of human thoughts. Philosophers must be attentive to the usage of words, symbols and language, but scientists do much the same for the advancement of knowledge. Hertz might prefer experimentation to “philology” and empty disputes concerning words, but he did a lot of conceptual work in *The Principles of Mechanics* and described his book plainly as the new interpretation of Newtonian physics.

Language of competing theories in science differs in lexicon, which is told to be incommensurable. There exists a break in communication among camps of theorists who support unlike paradigms or programs. Verbal, conceptual, methodological and value differences are responsible for the disunity of science. Many examples used by Kuhn to illustrate paradigm change were not subsequent, but competing ideas: geo- and heliocentrism, particle-wave theories of light, phlogiston-oxygen theories of combustion, Darwinism, and physical relativity. In alternative conceptual frameworks, the same terms are related to incommensurable meanings and unintelligible for minds not converted to a particular worldview and system of knowledge via learning, dialogue, practice, and experience.

In competing theories of evolution, the development of species is interpreted as neutral genetic drift or adaptive selection (Duret, 2008), or genetic scientists may define differently what genes and material of heredity are (Weber, 2004). When theories compete, they classify objects in alternative lexicons and semantic categories (Kuhn, Feyerabend), produce idealized models or typologies of objects (Max Weber, Ferdinand Tennis), create possible worlds and alien ontologies (Devid Lewis, Nelson Goodman). These worlds can be apt to union, re-combination, or mutual exclusion and annihilation. It takes time and efforts until conventional meanings are accepted by collectives and established by institutes of knowledge.

CASE-STUDIES IN HISTORY OF SCIENCE

Where propositional knowledge, proliferation of meanings, and misunderstanding are possible, hermeneutic techniques have been applied ordinarily: collecting papers, reading the text, getting into conversation, storytelling, reconstructing contexts, learning symbolic codes, and interpreting inputs holistically in light of the whole body of knowledge. Explication, definition, and clarification as logical operations are connected with the right reasoning and understanding of meanings, which turn out to be pluralistic in endless contexts of investigation when unification is a difficult task to accomplish.

In biblical hermeneutics, the *Alexandrian* and *Antioch* schools proposed symbolic and literal ways to interpret holy scriptures. Especially in early Christianity, readings of scriptures were pluralistic and did not follow official rules of faith, giving birth to heresies and misinformation. Scientific schools and intellectual traditions, whether in science or philosophy, are compatible with distinct hermeneutic perspectives on the same subject matter. In order to follow tradition, it is essential to have background knowledge and, else, understand values, conventional meanings, and the horizon of events. What Kuhn called paradigm is more propitious to scientific schools.

Natural theology in Christian tradition has read nature as a scripture written by the divine creator. In this context hermeneutic techniques are more than endorsed. Interpretation of creation makes it possible to understand God's intentions, acts, predestination and providence. Visible and changeable things lead to understanding of eternal and invisible forms of objects, incorporeal entities, the enigma of creation, and the first principles of existence. The revelation of God and his word is given in every material thing, living matter, bodies, and every soul. That is why nature serves as a source for understanding God's wisdom and architecture of universe. Typical questions of natural theology relate to how ordered nature can provide an evidence of divine creativity or how imperfection of nature is consistent with the greatness and the goodness of God.

St. Augustine in *The City of God* and St. Thomas Aquinas in *Summa Theologica* turned the attention to natural phenomena in connection with statements and symbols of the Bible and the corpus of religious texts. Augustine's *Christian Doctrine* is a treatise on biblical hermeneutics, mainly devoted to interpretation of canonical Christian writings. According to this treatise, natural signs and philosophical knowledge create a foundation for theology. In *Summa Theologica*, St. Aquinas (1485/2006) notes, "We cannot see the essence of God; but we know God from creatures as their principle" (L. 1, p. 2). Aquinas discusses the reference of names and predicates and divide names on those applied initially to things and metaphorically to God, and those applied immediately to God, which give knowledge of divine essence and causal power. Attributes of things make possible not only knowledge of abstract substances, but also divine qualities (absolute and affirmative names of God), and are used equivocally for reference both to creatures and creator. Naming things, clarifying meanings, decoding symbols, interpreting scriptures and natural signs are included in the exegetic practices of Christianity.

Tertullian considered science as a formation stage for religious consiousness; that is interesting to correlate with the contrary statements of positivists. He believed that philosophical descriptions of the world must be cleared up and improved by religious truth. Natural philosophy had stayed a subordinated field of studies in Christianity and did not advance much until the late Middle ages. Roger Bacon, a representative of medieval science and the monk of the Franciscan order, adopted methods of natural theology in his experimental research as complementary to knowledge of creation. Bacon (1773/1962) was convinced that "the grace of faith illuminates greatly, as also do divine inspirations in the sciences of philosophy" (p. 585). In the book *Opus Majus*, hermeneutic methods are used, particularly in the studies of medicine. Bacon says that humans could live much longer, but due to degradation of environment they have been living less than in times after the fall. Observing how animals avoid a premature death, humanity gets instructions for longevity. In general, humans should disclose the secrets of nature in order to retrieve from it instructions for medical treatment. In *Letter concerning the nullity of magic* Bacon rejected magical effects of incantations, symbols, numbers, and characters, which serve to express the laws of nature, but not supranatural powers. The philosopher rejected treatment based on signs and magical practices "pacifying evil demons" over approval of psycho-physiological efficacy of words and communication in medical therapy. If this approach to therapy somehow continues in narrative medicine, natural theology has a similar continuation in Intelligent Design theories in philosophy. Another remarkable writing in natural theology is Robet Boyle's *The Excellence of Theology, compared with Natural Philosophy* (1674) (McGrath, 2022), where rational knowledge, natural faculties, and physical arguments reveal God's creative power; origins, order and duration of universe; and beginning of human lives (Boyle, 1674/2017).

Beginning from the works of Fridrich Schleiermacher, Wilhelm Dilthey and neokantians, hermeneutics was nominated to be the exclusive method of human sciences, opposite to positive knowledge of nature and distinct from religious exegetic traditions. Earlier it was already introduced into the fields of philosophy, literary studies, politics and law (in jurisprudence, specifically, hermeneutic methods were applied in commentaries for *Roman law* and *Corpus Juris Civilis*). In modern technoscience there appear attempts to synthesize methods of soft and hard disciplines. Bruno Latour in actor-network theory has explained laboratory life and interactions of cognitive actors within laboratory settings in terms of hermeneutic practices — material semiosis, symbolic translations, exegesis of inscriptions, coding scriptures, networking and mutual understanding. In a sense, scientists own exclusive knowledge concerning nature, because it takes much effort to open black boxes of their experiments, reevaluate results and master a language. In last decades social sciences have been adopting quantitative methods, including computational and software techniques. Interpretive approaches are extensively applied by social scientists in connection with data analysis, computer simulations or ethnography research, that is the mixed method research. In the fields of computer science and artificial intelligence, results in linguistic studies, logic and psychology attract enormous attention. Boundaries are obviously dissolving, and technoscience exploits the original territories and methods of humanistic research.

Nordmann & Bylieva (2025) say that the "scientific idea of producing true representations is antithetical to hermeneutics as a process of understanding oneself by encountering and never quite understanding the other" (p. 10). He thinks that science does not presuppose conversion and change of the individual self. Nevertheless, the most famous theories in science have changed not only our beliefs and worldviews, but also self-perception, modes of behavior and social interactions, generally.

CONCLUSION

The presence of interpretation in scientific cognition can be associated with cognitive modeling itself, fitness of models to data and theories, understanding the lexicon of incommensurable theories, and philosophical questions of science. Models interpret the world(s) and are also interpreted in the subsequent theories, in philosophy of science and public discourse on essential worldview issues. Interpretation does not mean infinite replication of ideas, but theories and believes often come to be pluralistic. Idea of a "scientific model" illustrates it itself.

There is old intellectual tradition, rising from the ancient times, which warrants the application of hermeneutic methods in philosophical and scientific studies. In technoscience hybridization of disciplines and methods is a progressing tendency; in a result, there appear more research publications blending different methodological insights and scientific programs with hermeneutic techniques.

REFERENCES

Aquinas, T. (2006). *The Summa Theologica*. (Fathers of the English Dominican Province, Trans.). Burns Oates and Washbourne. (Original work published 1485) https://www.documentacatholicaomnia.eu/

Bacon, R. (1962). *The Opus Majus*. (R. B. Burke, Trans.). Russell & Russell. (Original work published 1773)

Baron, E. J. (1996). *Medical Microbiology* [4th ed.]. University of Texas Medical Branch at Galveston. https://pubmed.ncbi.nlm.nih.gov/21413252/

Boyle, R. (2017). The Excellence of Theology compared with Natural Philosophy. In M. Hunter and E. B. Davis (Eds.), *The Works of Robert Boyle, Vol. 8: Publications of 1674–6.* Pickering & Chatto. https://doi.org/10.1093/OSEO/INSTANCE.00249915 (Original work published 1674)

Burrell, C.J., Howard, C.R. & Murphy, F.A. (2016). Classification of Viruses and Phylogenetic Relationships. In C. J. Burrell, C. R. Howard & F. A. Murphy (Eds.), *Fenner and White's Medical Virology* (pp. 15-25). Elsevier. https://doi.org/10.1016/B978-0-12-375156-0.00002-3

Cartwright, N. (2008). Reply by Cartwright. In S. Hartmann, C. Hoefer, & L. Bovens (Eds.), *Nancy Cartwright's Philosophy of Science* (pp. 389-392). Routledge.

Dupre, J. (1981). Natural Kinds and Biological Taxa. *The Philosophical Review*, *1*(90), 66-90. https://doi.org/10.2307/2184373

Duret, L. (2008). Neutral Theory: The Null Hypothesis of Molecular Evolution. *Nature Education*, *1*(1), 218.

Hartmann, S., Hoefer, C. & Bovens L. (Eds.). (2008). *Nancy Cartwright's Philosophy of Science* (pp. 389-392). Routledge. https://doi.org/10.4324/9780203895467

Frigg, R. & Hartmann, S. (2020). Models in Science. *Stanford Encyclopedia of Philosophy*. Stanford. https://plato.stanford.edu/entries/models-sciences/

Knuuttila, T., Carrillo, N. & Koskinen, R. (Eds.). (2025). *The Routledge Handbook of Philosophy of Scientific Modeling*. Routledge. https://doi.org/10.4324/9781003205647

McGrath, A. (2022). Natural Theology. In N. Brendan & N. Wolfe (Eds.), *St Andrew Encyclopedia of Theology*. University of St Andrews. https://www.saet.ac.uk/Christianity/NaturalTheology

Morgan, M.S. & Morrison, M. (1999). Models as Mediators: Perspectives on Natural and Social Science. In M.S. Morgan & M. Morrison (Eds.), *Models as Mediators. Perspectives on Natural and Social Science* (pp. 347-388). Cambridge University Press. https://doi.org/10.1017/CBO9780511660108.003

Nordmann, A. (2008). Getting the Causal Story Right: Hermeneutic Moments in Nancy Cartwright's Philosophy of Science. In S. Hartmann, C. Hoefer, & L. Bovens (Eds.), *Nancy Cartwright's Philosophy of Science* (pp. 369-388). Routledge. https://doi.org/10.4324/9780203895467

Nordmann, A. & Bylieva, D. (2025). Hermeneutic Dimensions of Science and Technology. *Technology and Language*, *6*(2), 1-20. https://doi.org/10.48417/technolang.2025.02.01

Stanford, P.K. (1995). Pluralism and against Realism about Species. *Philosophy of Science*, *1*(62), 70-91. https://doi.org/10.1086/289840

Yeganehmehr, A. & Ebrahimnezhad, H. (2025). Classification of Galaxies from Image Features Using Best Parameter Selection by Horse Herd Optimization Algorithm (HOA). *Astronomy and Computing*, *50*, 1-13. https://doi.org/10.1016/j.ascom.2024.100898

Wassmann, J. & Bender, A. (2015). Cognitive Anthropology. In J. D. Wright (Ed.), *International Encyclopedia of the Social and Behavioral Sciences* (Vol. 4, pp. 16-22). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.12035-5

Weber, M. (2004). *Philosophy of Experimental Biology*. Cambridge University Press.

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Research article

Hermeneutics of Science – Technical Assessments and Hidden Horizons of Meaning

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Abstract

By writing, we inscribe the world around us and carve it into meaning. This idea of Jacques Derrida, which postulates that the function of the written text is not merely to describe but to actively create a new world, has found wide resonance across disciplines. Specifically, the article focuses on writing understood as a performative act of naming and classification – a universal mechanism of world-creation. This raises a critical question: can scientific texts, often seen as neutral descriptions of reality, also construct their own worlds, serving as horizons for creative interpretation and hermeneutic engagement? The article systematically examines arguments against applying hermeneutics to scientific texts, including their presumed transparency, reliance on empirical verification, and the formal rigidity of scientific concepts. Critics assert that scientific statements derive meaning solely from their correspondence to observable reality, leaving no room for interpretive ambiguity. However, the author counters this view by demonstrating how scientific texts, like artistic or philosophical works, generate their own contexts – whether through theoretical paradigms, “hidden worlds” of unobservable entities (e.g., atoms, social structures), or aesthetic criteria like elegance and simplicity. Examples from the history of science (e.g., Kepler’s laws, Weber’s Protestant Ethic) illustrate how scientific meaning emerges from interplay between formal statements and their interpretive horizons. Ultimately, the article advocates for a hermeneutic approach to science, revealing how scientific texts transform both their subjects and their readers, bridging the gap between empirical rigor and the creative construction of meaning.

Keywords: Science; Hermeneutics; Language; Naming and Classifications

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Научная статья

Герменевтика науки: Формальные критерии и скрытые горизонты смысла

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Аннотация

Путем письма мы выписываем мир вокруг нас и высекаем в нём смыслы. Эта идея Жака Деррида, утверждающая, что письменный текст создаёт новые миры, а не просто описывает существующий, нашла широкий отклик в различных дисциплинах. В данной статье мы рассмотрим письменные высказывания как перформативный акт именования и классификации – универсальный механизм миротворчества. В этом контексте поставлена главная проблема исследования: способны ли научные тексты, традиционно воспринимаемые как нейтральные описания реальности, в свою очередь конструировать собственные миры, становясь горизонтами для творческой интерпретации и герменевтического осмысления? В статье систематически анализируются *аргументы* против применения герменевтики к научным текстам и высказываниям. Эти аргументы опираются на их прозрачность, процедуры эмпирической верификации, а формализованность и строгость научных понятий. Особое значение имеет то, что научные утверждения обретают смысл через их соотнесение с наблюдаемой реальностью, что, как представляется, не оставляет места для интерпретационной неоднозначности. Соглашаясь в целом с этими доводами, автор тем не менее вводит ряд уточнений. В частности, показано, что научные тексты, подобно художественным или философским работам, порождают собственные контексты. К таковым отнесены: теоретические парадигмы, "скрытые миры" ненаблюдаемых сущностей (например, атомы, социальные структуры) или эстетические критерии вроде элегантности и простоты. Так, законы Кеплера, "Протестантская этика" Вебера и ряд других иллюстрирующих примеров показывает то, как научный смысл возникает во взаимодействии формальных утверждений и их интерпретационных горизонтов. В статье отстаивается герменевтический подход к науке. В частности, обосновывается, что научные тексты трансформируют как свои объекты, так и психологические установки читателей, что делает возможным преодоление разрыва между эмпирической строгостью и творческим конструированием смысла.

Ключевые слова: Наука; Герменевтика; Язык; Именование и классификации

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INTRODUCTION

There are good reasons for rejecting the hermeneutic interpretation of scientific texts.

First, it seems that a scientific text does not create its own world but only describes actual reality. If reality (in any of its forms – as a phenomenon, problem, theory, model or law, etc.) is described well, close to the original, and in detail, the task of the scientific text is considered accomplished and does not require additional efforts from the reader–interpreter. All readers extract identical meaning from it. Otherwise, the text simply did not solve its task: either the author failed to reflect reality, or the reader does not have the necessary qualifications.

Second, scientific concepts, unlike words of natural language, are quite transparent and are initially defined within the framework of formal language or as background scientific knowledge. The meaning of scientific concepts does not change depending on the situational context of their use, as is the case with words of natural language. Otherwise, it would have been impossible to achieve scientific consensus (relative to the solution of the problem even if not to the meaning of concepts). If each scientist had understood mass or energy as something special depending on a specific situation, scientific consensus at this level would have been impossible.[1]

Third, the hypothetical referents of scientific descriptions must square (or not square) with empirical data. Their objective meaning (truth or falsity) is determined by the factual circumstances of a state of affairs, not involving the broad communicative and hermeneutic horizons that determine the sense or meanings of artistic texts and works of art: such as artistic styles, the character of the era, the socioeconomic situation, the author’s education.

These horizons or worlds are on the one hand created by the works of art themselves, and as a whole, on the other hand, they hermeneutically determine the meaning of these works.

It is precisely this circular interdeterminacy of some such whole and its parts as manifestations of this whole that constitutes the famous hermeneutic circle.[2] Obviously, in trying to understand an artistic statement, we will not find *a single and unambiguous basis* that would guarantee an unambiguous understanding of the artistic work, whereas such as basis is evidently presupposed in a scientific text in the form of empirical data

1 The words of natural language differ from the concepts of science, but this does not hinder understanding but rather launches the process of hermeneutic interpretation: the search for explanatory contexts through questions, clarifications, attempts to resolve ambivalent statements and omissions. For example, if we knew everything that the communication partner really meant, it would soon have become clear that the presenter wants not to help gain insight in the product but just to sell it. The politician does not want to promote the public good but to retain power. The admirer does not want love but sexual fulfilment. Full understanding in everyday communication is impossible, and this is precisely why it prompts communication.

2 See the first formulation of the hermeneutic circle by Friedrich Ast who also coined the term: “if we can know the spirit of all antiquity only through its revelations in the works of writers, and they themselves possess knowledge of the universal spirit, then how is it possible ... to know the individual, since this presupposes knowledge of the whole?” (Ast, 1808, p. 179).

and formal clearness of concepts. In contrast, to understand the sense of an artistic statement means to understand those distinctions or traces that the artistic text has produced in the reader's own consciousness; "Without a trace retaining the other as other in the same, no difference would do its work and no meaning would appear" (Derrida, 1967, p. 62).

WHAT SPEAKS AGAINST THE HERMENEUTICS OF SCIENCE?

The distinction between artistic and scientific statements seems obvious. However, the assertion that a hermeneutic understanding of a scientific text is impossible simultaneously implies that such research directions as social epistemology and STS lack a disciplinary foundation.

Social epistemology connects the formulation of true scientific propositions not only with actual states of affairs as their causes but simultaneously records a certain additional causality – social contexts and horizons of scientific communication – the horizons that causally participate in the generation of true scientific statements and therefore must be considered for their understanding. This social-world context determines the meaning of the statement and, at the same time, is formed by this scientific statement. After all, a scientific statement always "means" something for the social external world of science.

In general, it is difficult to get rid of the feeling of the paradoxical nature of the question of understanding: a *complete* understanding of a scientific statement is precisely what prevents its hermeneutic interpretation – in the sense that the unambiguously interpreted and formalized concepts of scientific texts, the internal consistency of scientific statements, their integration into some more general theory and paradigm, the given rules of their empirical verification leave the reader almost no room for interpreting what has been read. Simply put, all scientific texts are equally transparent to a competent reader since they are all either true or false, or unscientific, and the (social and other) contexts of their generation, the contexts of discovery, as is known, are not related to the contexts of justification.

Any sufficiently erudite or socialized reader will find in them universally identical information, with which all participants in scientific communication must agree.[3] It follows that the reader does not emerge from the reading process *individually* transformed or enriched since the structure of horizons that determines the meaning of what is read, which is common to all participants in scientific communication, does not change. The scientific text rather standardizes than enriches the recipient's subjectivity. After all, the horizons of the meaning of the text under interpretation (background knowledge, paradigms, methodology, normative and cognitive attitudes of the author and reader, algorithms of understanding) are essentially identical for all members of a given scientific community, in which understanding takes on the character of automatisms.

3 Even if we mean different solutions to a scientific problem among different participants in communication, the opposing sides must agree at least with the index of the *problematic nature* of the statements (as a *truth/falsity* that has not yet been determined). Otherwise, they would simply not participate in the scientific debate.

Concerning the question of understanding a scientific text thus differs significantly from an artistic, political, or poetic text or work. In the latter case, readers experience a certain idiosyncratic impression that changes the structure of their horizons and the character of their personality. They become different persons in and through the process of reading, since the cognitive and normative structures of consciousness themselves change along with the perceived work. Readers build bridges with a new and complex world, so distant from theirs that it becomes necessary to fill the resulting distance between the statement read and its interpretation. These bridges require the interiorization of new psychological attitudes. In different hermeneutic approaches, this distance was supposed to be bridged by different processes. Empathic attitudes provide understanding in Wilhelm Dilthey, and the continuity of tradition ("*Wirkungsgeschichte*") in Hans Gadamer.

In relation to scientific texts "symbolically generalized media" play the role of such an intermediary that bridges the communicative distance between author and recipient. By way of these "symbolically generalized media" of communication (money, power, truth, love, faith, etc.) meaning (information) is extracted from these texts (Luhmann, 1998).

In a modern functionally differentiated society, the role of these communication mediators renders communication technical by facilitating, accelerating, automating, algorithmizing it. In today's fast-paced world, there is no time to think about the true meaning and context of communicative requests and messages. They must be accepted or rejected on the basis of certain programs or algorithms, i.e. a certain technique. Thus, a message in the form of an offer of a product speaks for itself; there is no point in attracting interpretive horizons and thinking about the motivations of the communication partner. The same applies to the automatic acceptance of an order by the authorities. This holds for scientific communication as well which is also extremely technicalized and automated. After all, scientific communication cannot do without a *symbolically generalizing* mediating function (Luhmann, 1992). On the one hand, any scientific text *generalizes* a set of specific situations (for example, in the form of generalizing descriptions, models, laws, or methodologies). On the other hand, it is oriented toward common symbols that ensure a scientific consensus among a given community of researchers who are qualified in a given field.[4]

Thus, an article prepared according to the rules of a scientific journal and provided with scientific affiliation will be reviewed according to the algorithms for assessing contemporary knowledge (design requirements, peer-review standards, editorial board decision-making algorithms, etc.). Scientific editorial boards serve as conveyor belts for assessing, accepting, and rejecting knowledge. Under such technicalized and algorithmic conditions, appeals to the principles of *exegesis* would only complicate scientific

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4 Of course, truth as a symbol of consensus is in itself an empty and meaningless index, a two-sided form of *truth/falsehood*. The meaning of its application consists only in indicating the binary necessity – either acceptance or rejection of the text as a communicative request for contact. However, this index is the result of the previous implementation of a number of methodological procedures for checking and validating knowledge in accordance with the theoretical and methodological *programs* dominant in science. Similarly, in other communicative spheres (economics, politics), the indexes (money, power) that are meaningless in themselves receive a symbolic meaning as providing orientation due to the prior implementation of economic and political programs.

communication. Reference to the author's situation, biography, education, or sociocultural context would hinder the decision on whether to accept or reject the text.

Today, the decision on the acceptance of knowledge is extremely automated and technicalized. The expert has a list of technical criteria for good text which are well known also to the authors of scientific texts. These criteria include the clarity of the thesis, allowing for an unambiguous *yes/no* answer; the formulation of the problem in the form of mutually exclusive solutions; the validity of the arguments; novelty; relevance; transparency; breadth of review; structuring; and the use of the latest literature. In this sense, the assessment of a scientific text is extremely routinized – focused on the *strategic* goal of scientific *success* but not on *consensus* and the search for *mutual understanding*. After all, reviewers and editorial boards do not as a rule share *empathy* in the sense of *Dilthey*, do not show understanding for the position of the author, do not interpret someone‘s article in light of their situation in life, and do not consider texts that have lost their relevance in the context of their "*Wirkungsgeschichte* [Era of Efficacy and Influence]" etc.

Does this mean that the realities of the life world of the author of a scientific text have ceased to serve as a basis for understanding the scientific text?

HORIZONS OF HIDDEN WORLDS AS A CONDITION FOR THE HERMENEUTICS OF SCIENTIFIC STATEMENTS

Despite all this we are not inclined to completely deprive scientists of that self-transformation and hermeneutic empathy that is characteristic of the perception of artistic and other nonscientific texts.

Often, interpretations of data and their theoretical context unexpectedly appear in the format of a gestalt switch. As a result of a change in theoretical context otherwise identical data become subject to the same "*Wirkungsgeschichte*" that is characteristic of artistic statements. Thus, Tycho Brahe and Kepler, standing on a hill, seem to perceive the same thing. However, Tycho Brahe sees the sun rising over the horizon, while Kepler sees the horizon descending (Hanson, 1958, pp. 5-24).

At the same time, the formal theories themselves also have their own "history of action." Having lost the status of true and being recognized as false, theories change their interpretive meaning and context, limiting themselves to the framework of their "applicability," but are also interpreted for their significance for the history of science, for the social determinants of their creation, etc.

Another circumstance, connected with the contexts of hidden reality as a condition for the hermeneutic understanding of scientific statements, has even greater hermeneutic significance:

Formulas describing the correlation of certain variables (for example, temperature, pressure, and volume) do not appear to require hermeneutic empathy or reconstructions of hypothetical horizons for their interpretation since the said variables are already formally defined in the language of science and have well-known sensory empirical correlates (temperature can be felt). At the same time, however, it turns out that a change in temperature is explained not only at the phenomenal-data or human-dimensional level, allowing for sensory verification. Reconstruction of deep contexts is required and, as a consequence, a “deeper” understanding of the hidden reality, one might say, the hidden world, structures hidden from the eye (Harré, 1970). The scientist seeks to understand the correlations of variables, turning to the “hidden world,” the opaque world of atoms and molecules, theoretical entities, not directly accessible but requiring “existential” interpretation. They are the hypothetical “generative mechanisms” of human-dimensional phenomena.

Accordingly, Rom Harré declared that “scientific explanation consists in finding or imagining plausible underlying generative mechanisms for the patterns amongst events, for the structures of things, for the generation, growth, decay, or extinction of things and materials, for changes within persisting things and materials” (Harré, 1970, p. 125).

These underlying generative mechanisms help us “understand” a formalized statement since they visualize the connections of variables, whether we are talking about a planetary model of an atom or a cloud of molecules that behave according to the ideal gas model. Note that a formal statement describing a reality hidden from the eyes can include quantities that are in no way correlated to processes of measurement, quantities for which no instrumentally measurable correlate is found in reality at all, thus significantly expanding the interpretive horizons. [5]

These hidden visualizing hypothetical mechanisms for generating phenomenal reality as a condition for interpreting a scientific statement represent a special world, hypostatized for explanatory purposes. This world is constructed by scientists to fill the distance between a scientific statement and the reader’s ability to understand this text.

In the social sciences, for another example, the scientist is not satisfied with formal connections between variables. Thus, Max Weber searches for deep foundations for the mutual dependence of “Protestantism” and “capitalism,” therefore reconstructing “hidden” causal mechanisms at the microlevel. According to Weber, these “hidden causal mechanisms” consist in the influence of the doctrine of Protestantism, generating the psychological attitude of “innerworldly asceticism.” This psychological attitude itself, in turn, causally generates mass economic actions, leading at the next step of causation to the formation of macrostructures of the capitalist system.[6]

Here too, an opaque world of mental attitudes is postulated, a world hidden in the inaccessible locality of consciousness. The psyche is just as opaque and inaccessible to the perception and understanding of the scientist as is the invisible cloud of molecules in kinetic molecular theory. This reconstructed mental world is the result and condition of the interpretation of global historical dependencies. Mental “generative mechanisms,” invisible to the external observer, form that very hypothetical, phenomenally inaccessible world and context that is imagined by the scientific interpreter as a condition for

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5 As Campbell noted, dictionary entries can be assigned only to some terms of a theory. According to Campbell, it is not necessary to associate each hypothetical term with experimentally verifiable statements to achieve empirical significance for the theory as a whole. Thus, in kinetic theory, relationships are established between the masses and velocities of individual molecules. However, the variable that has individual molecular velocities as its physical correlate has no empirical values or “dictionary entries” of its own (Campbell, 1956, p. 122).

6 For more detail on this microfoundation of the macrolevel of science, see Coleman, 1987.

understanding the movement of history. These deep causations – invisible to the naked eye – open new horizons for the interpretation of formalized statements of science.

THE AESTHETIC DIMENSION OF SCIENTIFIC STATEMENT

Such speculation about hidden external world correlates of transparent mathematical formulas, among other factors, introduces an additional context – the aesthetic dimension of scientific texts. One speaks, for example, of an “elegant solution to the problem,” when certain heterogeneous realities or variables reveal a deep unity or integrity, as a homogeneous world basis for interpreting heterogeneous relationships. Thus, Newtonian theory elegantly reduced to unity the phenomena of tides, falling bodies, planetary orbits, pendulum oscillations, etc.

A theory is beautiful if it provides a generalized description of phenomena that seemed unrelated but are now united within one aesthetically appreciated whole. And this presentation and explanation of the part through the whole is a typical procedure of the hermeneutic circle. Thus, Kepler’s discovery of his third law became, from his point of view, a striking testimony to the universal divine mathematical connection of things, the so-called “Pythagorean principle” (Harré, 1965), as a general explanatory context for astronomical correlations. This law asserted a mathematical correlation between planetary distances and orbital velocities. Through a reference to the *invisible* elliptical orbits of celestial bodies as the physical meaning of this formula, the law had as its basis the unity of divine mathematical design, the hidden causal mechanism of causation, and was perceived as aesthetically elegant.

The self-vindicating mathematical form of the third law, confirmed by astronomical observations of celestial bodies, namely the reference to an invisible physical correlate (some hypothetical universal plan of the Creator), makes possible an additional interpretation through the explanation of heterogeneous phenomena (planetary distances and planetary velocities) within the framework of a single world. This world acts as an interpretative context for the formalized statements and texts of Kepler himself.Accordingly, the philosophy of science is also developing formal–aesthetic *criteria* for evaluating a good scientific theory (McAllister, 1996) as additional grounds for evaluating a scientific statement. Visualizability, symmetry, explanatory simplicity, ontological economy, and other criteria of the aesthetic canon complement the classical “logical–empirical” criteria for validating formalized statements, which supposedly eliminate the need for a hermeneutic interpretation of the text. In this regard, James McAllister, but also Thomas Kuhn[7] record a certain set of expectations that are equally applicable to both theoretical descriptions and phenomenal descriptions of nature, society, and man. These expectations bring scientific and artistic texts closer together, affirm the unity of science and the life world, which represent, aesthetically connected, even if separate, parts of the *integral* world, and therefore, in turn, require the implementation of the hermeneutic circle.

7 McAllister divided Kuhn’s standards for assessing a good theory into invariant logical–empirical criteria and – revised during scientific revolutions – standards of aesthetic perception.

AMBIVALENCE OF THE LANGUAGE OF SCIENTIFIC CONCEPTS AS A BASIS FOR APPLYING THE HERMENEUTIC METHOD

In the discussed dilemma of *transparency/hermeneutics* of scientific language, famous philosophers of science sometimes express ambivalent judgments. Thus, Thomas Kuhn, it would seem, categorically maintains that we understand each other because we are speaking the same language. Nevertheless, in other contexts, Kuhn is much less categorical. The language of science, in his opinion, has not yet reached a sufficient stage of maturity and generality, which means that translation (a kind of hermeneutic interpretation) of scientific terms is required.

Thus, in the second edition of *The Structure of Scientific Revolutions*, regarding his understanding of the language of science, Kuhn largely departs from the ideas of Nelson Goodman and draws on Willard van Orman Quine’s concept of the indeterminacy of translation. Kuhn describes this hermeneutic procedure in some detail:

“…what the participants in a communication breakdown can do is recognize each other as members of different language communities and then become translators. Taking the differences between their own intra- and inter-group discourse as itself a subject for study, they can first attempt to discover the terms and locutions that, used unproblematically within each community, are nevertheless foci of trouble for inter-group discussions. (…) Having isolated such areas of difficulty in scientific communication, they can next resort to their shared everyday vocabularies in an effort further to elucidate their troubles. Each may, that is, try to discover what the other would see and say when presented with a stimulus to which his own verbal response would be different” (Kuhn, 1970, p. 202).

In this new interpretation of the language of science, concepts lose the unambiguous certainty and transparency of their semantics. Now, external-world correlates of scientific concepts are not localized by Kuhn in the other-referential objective world. Kuhn calls the meanings of these concepts “stimuli” and localizes them in the mutually *inaccessible consciousnesses* of scientists. For an adequate interpretation and understanding of the speech of another scientist, a procedure of “empathy” is now required, which ensures the desired understanding of the Other. Now, in accordance with Quine's behaviorism, a stimulus hidden in consciousness or the experience of an object in the perception of an observer acts as a semantic correlate of scientific concepts.

INSTEAD OF A CONCLUSION: HOW SCIENTIFIC TEXT TRANSFORMS SCIENTISTS

Kuhn’s psychologization of the referents of scientific concepts makes it possible to clarify the answer to the question whether a scientist is transformed by encounters with scientific texts Now we can object to the argument that scientists are “impersonal knowing subjects.” From our point of view, scientific texts can significantly transform the character of the personalities of scientists, who are often far from mentally and emotionally indifferent or merely objective observers of nature.

Of course, from the point of view of Popperian falsificationism, the researcher must react indifferently to the experimental confirmation of a theory which does not prove anything. At the same time that researcher must stoically endure, and even positively welcome, its falsification. However, it seems that this ethos of falsificationism prescribes rather than describes the actual behavior of the scientist.

The history of science provides many examples of scientific controversies which seriously affected at least the emotional structure of the psyche of scientists – remember, for example, Einstein's lambda and his disappointment in this idea[8]. This shows that the development of an important hypothesis or a breakthrough idea, and especially their subsequent theoretical or experimental refutation, polemical counterarguments, nonrecognition in the scientific world, can become a deep personal experience and disappointment that remains with the scientist for life.

In general, the idea of a scientist as an objective and indifferent observer of nature contradicts the motivational attitudes of the scientist's consciousness. In his lecture "Science as a Vocation" Max Weber beautifully describes the nature of scientific passion:

"Without this strange intoxication, ridiculed by every outsider; without this passion, this 'thousands of years must pass before you enter into life and thousands more wait in silence' – according to whether or not you succeed in making this conjecture; without this, you have no calling for science and you should do something else. For nothing is worthy of man as man unless he can pursue it with passionate devotion" (Weber, 1922, p. 531).

As we have shown above, the scientist is looking for the "hidden causal mechanisms" that do not lie on the surface of the empirically accessible world. This brings the production and analysis of scientific texts closer to reading a detective story, to fiction. The scientist emerges from the scientific text as a different person, no longer believing in what lies on the surface of human-dimensional space-time, the realities of everyday life, where the sun revolves around the earth, mass does not increase with speed, and time does not slow down. The meaning of the scientis's work lies in the fundamental distinction between "What is the case [*Was ist der Fall*]" and "What's behind it? [*Was steckt dahinter*]" (Luhmann, 1993). A scientific text, like a work of fiction, is guided by the communicative code of novelty and uncertainty, creates intrigue to resolve it, reveals the surprising and unexpected. However, while fiction immediately declares itself as fiction, science, on the contrary, asserts its constructions and models, its electrons, dark matter and energy, or superstrings, as a deep and mysterious, the only possible and actual reality.

REFERENCES

Ast, F. (1808). *Grundlinien der Grammatik, Hermeneutik und Kritik*. Landshut.

[8] Einstein introduced the cosmological constant (Λ) in 1917 to maintain a static universe, as prevailing scientific thought at the time suggested. However, after Edwin Hubble's 1929 discovery of the expanding universe, Einstein reportedly called Λ his "biggest blunder" (Gamow, 1970, p. 44), as it seemed unnecessary.

Campbell, N. R. (1957). *Foundations of Science*. Dover Publications.
Coleman, J. S. (1987). Microfoundations and Macrosocial Behavior. In J. Alexander, B. Giesen, R. Münch, & N. Smelser (Eds.), *The Micro-Macro Link* (pp. 153–173). University of California Press.
Gamow, G. (1970). *My world line: An informal autobiography*. Viking Press.
Derrida, J. (1967). *Of Grammatology* (G. C. Spivak, Trans.). Johns Hopkins University Press.
Hanson, N. R. (1958). *Patterns of Discovery*. Cambridge University Press.
Harré, R. (1965). *The Anticipation of Nature*. Hutchinson.
Harré, R. (1970). *The Principles of Scientific Thinking*. Macmillan.
Kuhn, T. S. (1970), *The Structure of Scientific Revolutions* [2nd ed.]. Chicago University Press.
Luhmann, N. (1992). *Wissenschaft der Gesellschaft*. Suhrkamp.
Luhmann, N. (1998). *Die Gesellschaft der Gesellschaft*. Suhrkamp.
Luhmann, N. (1993). “Was ist der Fall?” und “Was steckt dahinter?”: Die zwei Soziologien und die Gesellschaftstheorie. *Zeitschrift für Soziologie, 22*(4), 245–260.
McAllister, J. (1996). *Beauty and Revolution in Science*. Cornell University Press.
Weber, M. (1922). Wissenschaft als Beruf [Science as a Vocation]. In *Gesammelte Aufsätze zur Wissenschaftslehre* (pp. 524–555). Mohr.

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Research article

Hermeneutics of Science: New Metapolitics of Institutional Order

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Abstract

This article examines the validity of the hermeneutic method in the analysis of science and technology. The scientific method is considered to be objective, rational and extra-contextual, which conceptually corresponds to the ideals of science since the Enlightenment. At the same time, the hermeneutic method, which presupposes dialogue, plurality of interpretation and deep embeddedness in the cultural context, has been considered exclusively in the methodological context of the humanities. The transformation of discussions in the philosophy of science, marked by the transition to the Kuhnian language of the self-description of science, led to a further deepening of research into questions of its institutional nature. Critical studies by Alfred Nordmann, Don Idhe, Robert Crease and Andrew Feenberg show from different angles show different facets of using hermeneutic within and beyond academia. Hierarchies, especially those that regulate institutional scientific life, use the mechanisms of metapolitical control. Notions of the institutional order of science are a result of the hermeneutic method applied to it in an obscure way. The outcomes are sociotechnical imageries, habits of thought, certain models of technological design and the public image of science as a neutral and operationally autonomous institution. The study demonstrates that this is caused by the use of the hermeneutic method as an instrument of metapolitics. Its legitimation within the framework of scientific practices, embodied in the projects of sociology of science, feminist philosophy of science and critical theory of technorationality has borne its first fruits. It is also leading to a drastic shift in the application of control mechanisms. The change in attitude towards cultural embeddedness, contextuality and the possibility of hermeneutic analysis of scientific objects and processes fundamentally restructures the scientific ethos.

Keywords: Institutional Order; Systematics; Scientific Institutes; Hermeneutics; Taxonomy of Science; Metapolitics; Technoscience

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Научная статья

Герменевтика науки: Новая метаполитика институционального порядка

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Аннотация

Статья посвящена исследованию вопроса о допустимости использования герменевтического метода при анализе науки и технологий. На протяжении длительного периода развития исследовательских практик научный метод рассматривается как объективный, рациональный и внеконтекстуальный, что концептуально соответствует идеалам научности. В то же время герменевтический метод предполагающий диалогичность, множественность интерпретаций и глубокую укорененность в культурном контексте, до последнего времени рассматривался исключительно в методологическом контексте гуманитарных наук. Трансформация дискуссий философии науки, отмеченная переходом к кунианскому языку самоописания науки, привела к дальнейшему углублению исследований в вопросах ее институциональной природы. Критические исследования А. Нормана, Д. Айде, М. Криза и Э. Финберга с разных сторон демонстрируют, что ограничение на использование герменевтического метода связано не с внутинаучными, а социальными причинами. Общественные иерархии, в частности регулирующие институциональную научную жизнь, обладают механизмами метаполитического контроля. Институциональное упорядочивание науки при этом является следствием применения герменевтического метода в отношении нее самой. Результатом становится создание и воплощение социотехнических образов, привычек мышления, определенных моделей технологического дизайна и публичный имидж науки как нейтрального и операционально автономного института. В заявленном исследовании показано, что все это является результатом скрытого использования герменевтического метода как инструмента метаполитки. Показано, что его легитимация в рамках научных практик, воплощаемая проектами социологии науки, фемининстсткой философии науки, критической теории технорациональности, приводит к смещению механизмов контроля обозначенных иерархий в реальные научные практики. Смена отношения к культурной укорененности, контекстуальности и возможности герменевтического анализа объектов и процессов науки принципиально перестраивает научный этос.

Ключевые слова: Научные институты; Герменевтика; Систематика; Институциональный порядок; Таксономия науки; Метаполитика; Технонаука

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INTRODUCTION

The natural, technical and human sciences are known for their mutual enrichment and borrowing of metaphors. The latter are interpreted differently in various fields of scientific research and undergo changes of meaning, which is the very idea of interpretation. The crisis of a "key metaphor" (and we can name a few) and the exhaustion of its use often coincide with the crisis of research itself (as happened with the use of the metaphor of the brain as a computer). At the same time, the sustained practice of such exchange is not taken seriously in terms of its contribution to the methodology of science and technology. More radically, it is devalued. Similar mechanisms are at work when researchers seriously claim the fruitfulness of applying of the hermeneutic method in science and technology research. The use of the method associated with the names of Friedrich Schleiermacher, Paul Ricoeur, Hans-Georg Gadamer, Wilhelm Dilthey has not been taken seriously in relation to sciences other than the humanities until recently. The familiar but rather crude division into fields of research and methods that characterises them conceals a deep institutional conflict as well as complex mechanisms that maintain the stability of existing social hierarchies. Here we will address the issues of "habits" of institutional thinking and sociotechnical formation of imageries. In addition, a brief excursion into the twentieth century's "history of methodological confrontation" will help us to understand its impact on the ethos of science and the design of technology. Using the tools of the critical theory of technorationality, we will try to uncover the hidden metapolitical mechanisms that ensure the public neutrality and operational autonomy of science and technology. The final task of this study will be an attempt to show how the methods of democratisation and humanisation of science and technology correlate with the basic principles of hermeneutics.

IMAGINATION IN ACTION: THE 'THINKING' OF INSTITUTIONS IN RELATION TO SOCIOTECHNICAL IMAGINARIES

In one of her most important works, "How Institutions Think", Mary Douglas begins by identifying a key complexity in relation to the proposed study. She begins with the fact that the sole definition of collective behaviour is problematic, despite the existing examples of class behaviour, given by Marxist theorists, or collective will, presented in theories of democracy. Nevertheless, Douglas resolutely constructs her in-depth analysis by showing the application of the hermeneutic method to and by the institutions themselves. Scientific organisations are ascribed certain qualities and behavioural strategies that are different from those of their independent members. Thus, an institute does not have a "mind of its own", but it assigns identities, categorises, "remembers" and "forgets", and makes "life and death" decisions. Institutions also classify, creating their own scientific frameworks and behavioural strategies. They interpret the scientific world, its objects, discoveries, debates and extra-institutional realities, and build models of interaction with internal and external actors of science – scientists and their collectives, the state, political and civil associations and the economy. Institutions interpret all kinds of realities around them, and this is a key factor in their survival, prosperity, competitiveness and right to participate in public life. Discursively and institutionally sedimented "habits of mind" are what shape and transmit sociotechnical imaginaries, as Nordmann points out with reference to Sheila Jasanoff (Grunwald, et al., 2023 p.39). Sociotechnical imaginaries ultimately become significant not only for theoretical reflection on the philosophy of science and technology, but also lead to the implementation of specific behaviours, or as Jasanoff notes, "our sense of how we should organise and govern ourselves profoundly influences what we make of nature, society, and the "real world"" (Jasanoff, 2015, p. 3).

The sociotechnical imaginary is used, on the one hand, methodologically – to fill a gap in research on image construction in political and cultural theory. On the other hand, it is used in STS to mark the circumstances that make it possible to refer to these imaginaries and their constitutive elements in the course of analysing the interrelation of technology and social life.

Let's turn to an alternative account of imagination offered by Appadurai (2002). He draws attention to its systemic organisation and form of social work, deliberative practices, and sees them as multiple and diverse attempts to negotiate how we imagine a world of optimal social order. This radicalised model of imagination as a stable source of social and technological change demystifies the category of imagination itself while instrumentalising it. As will be shown below, the category of instrumentalisation is of great importance in the context of the critical theory of technorationality. According to its basic tenets, primary instrumentalisation severs the connection between technological artefacts and the environment, thus depriving technology of its contextuality. The so-called "second instrumentalisation" does the opposite through the process of humanisation, reconstructing people's relationships with technology and with each other according to new principles. In this respect, the hermeneutic method applied to technology also becomes a way of interpreting the forms of social life, hopes and desires, especially those realised through the technological products of design.

THE METAPOLITICS OF TECHNOLOGICAL DESIGN: WHY WE ARE NOT ALLOWED TO USE THE HERMENEUTIC METHOD

Feenberg discusses similar issues from a different perspective in his reflections on technological design. Like Jasanoff, he considers that material artefacts are filled with a range of meanings, from the personal to the ideological. At the same time, technological design is a field far from the realisation of humanistic and democratic ideals. This implies limited access for prospect creators to realise the models of technological design. Moreover, at the level of public institutions, the very interpretative meanings of embodied technological designs and artefacts is an ideologised and monopolised field.

Such close attention to sociotechnical imaginaries is partly due to the image of a successful society as such: a society of dominant rationality, especially techno-rationality. Superficially, the criteria of backwardness or progress are based on the level of technological development and autonomy. That is, the emphasis is on the performative part, which can be expressed visually. Visual expressions mean here the embodied imaginaries range from statistical data on sectoral or territorial development to technological infrastructure and architecture, which become discursive statements about the level of progress.

The field of technological design cannot remain neutral and apolitical. It is linked to the realisation of a certain technological policy. The project of technodesign, starting with the choice of the form in which technology is embodied, is closely linked to the social context of its realisation. Ultimately, it is a process of continuous redefinition of what it means to be human, as a consequence of the constant increase in the level of technology. There is a parallel between sociotechnical imaginaries and their practical embodiment in concrete design. It is difficult to determine exactly why one imaginary dominates within a particular community (large or small). Nor can we understand the basis on which a choice is made between two equally technologically effective alternatives. In epistemological research, this problem is called the "vis-à-vis problem": if we have two coherent, internally consistent models, what is the basis for our choice?

As researchers and simply as members of society, we are confronted with the internal contradiction of the situation of the imposed rational method, "purified" of sociality. At the same time, it is difficult to escape the realization of the fundamental impossibility of adequately reflecting the images of the social and scientific order that exist apart from the fact of its institutionalization. The notion of technical code becomes an indication of the inseparable link between social structure and technology. It reflects the social foundations of this or that type of society, which is the basis of the embodied technological design. The stability of the code is a guarantee of the sustainability of the functioning of existing social hierarchies and institutions. At the same time, the neutrality of technology often coexists with the idea of its autonomy. The latter, however, is merely an instrument of stable hierarchical control. The technical code reflects and becomes the material equivalent of the social relations to which it is subject.

Public vocabulary is associated with the neutrality of science, while contextuality is perceived negatively. Although this dichotomy seems outdated, especially in light of the large number of studies on the sociology of science, it still holds true in the space of public discourse on science and technology. According to Idhe, "there is no such thing as "mere use" of technology" (Idhe, 1998, p. 47). This is also suggested by the idea of multistability of technology that was proposed by him. According to him, the plurality of purposes for which technology is used makes it possible to include it in a variety of contexts. Here, neutrality is followed by a conceptualization of expertise expressed in the name of a conditionally objective scientific position. Contextuality, on the other hand, is associated with politics, along with personification, bias, emotionality, and ambiguity. What a politician can afford in a public debate, an expert, deprived of individual will in his function as translator of the position of the scientific community, cannot. Contextual science is a "bad" science that does not correspond to the idea of universal ideals, constituted during the Enlightenment. Therefore, preserving the public image of science as a neutral autonomous entity and technology as a neutral functional field of practice is the most effective way of political management of institutions.

However, what is seen as an advantage of a technocratic device, i. e. operational autonomy, has the disadvantage of hindering trust and reliable communication (Feenberg, 2017). The neutrality of technology cannot be seen as something that is simply given at the outset. It is the result of a process of decontextualisation, which means that it removes some of the content of objects and excludes them from the system of relations and coordinates that define them. In particular, the environment that determined the dynamics of their development. This process reflects the idea of primary instrumentalisation, where objects are attributed technical rather than substantive properties. The consequence of this can be their inclusion in a system in a “reassembled” form, with the subsequent attribution of some new emergent properties to the system itself, in other words its ideologisation.

One of the dominant considerations of the stated research is the idea that the hermeneutic method applied as a metapolitical method to science and the same method applied as a research strategy for science itself have different objectives. The seeming contradiction in its evaluation is not the case: applied to structurally different fields - science policy aimed at maintaining existing social hierarchies and scientific activity aimed at qualitative progress of science and results transforming our reality and understanding of the world. For metapolitics, hermeneutics is a tool for the ideologization of science, especially through the attribution of definitions. The practical reflection of this attribution is the image of neutral technology. Moreover, in addition to neutrality, possible public objections to it are always stipulated. A public objection may, for example, become apparent in a discussion about nuclear power. The discussion is constantly fluctuating, operating with a wide range of definitions, from “peaceful atom” and “cleanest energy” to the constant threat of nuclear technologies being developed. At this point, the question of technology also becomes a problem along the axis of “humanization – dehumanization” of technology.

A bold suggestion is that the hitherto controversial position of the hermeneutic method in science can be considered not only in the context of the changes outlined above and the field of interest and methodological descriptions of scientific and technological research. This problem is conventionally divided into the meta-level of science and technology politics on the one hand, and the fields of scientific research themselves on the other. The application of the hermeneutic method is not limiting, on the contrary, its use potentially gives “too much freedom” and diversity in the creation of narratives, in terms of the existing metapolitical hierarchy. The potential consequence of this is the destabilisation of existing technological and, consequently, social relations. This is why, when it comes to the creation of radical new technologies or breakthrough scientific research, the language of science is replaced by the language of politics. “Revolutionary technologies”, “scientific revolutions” are phrases that mark the destabilisation of the existing hierarchical order. They mean that the usual ways of instrumentalisation are no longer effective, and so they can lead to the destruction of the established order or, to use Feenberg's terminology, to a change in the technical code.

The use of the hermeneutic method radicalises the world of science. It becomes more than a mere choice of an equivalent alternative. Rather, the change will be more like a shift from method to metamethod, leading to a revision of the conceptual apparatus of science and the value status of certain established categories. In fact, this has already happened during the heyday of feminist philosophy of science and standpoint theory (Harding, 1988, 2008, 2015). However, despite the fact that such studies have been around for 30-40 years, it is difficult to assess their impact on the actual practice of science. Nevertheless, it is possible to see in this approach some methodological indications for overcoming the idea of scientific universalism and for broadening the optics of research. It is therefore possible to draw a parallel between these directions and the idea of Idhe, who expresses reflections on the deep embeddedness of technology in culture, which has been denied for decades with astonishing persistence. The researcher concludes that there are no technological transfers, only cultural-technological ones.

The reason for this lies in the original institutionalisation of science and its associated traditions and habits of thought. This echoes the idea that “hermeneutics as a methodological practice mobilises the critical subject and producer of meaning against the implicit “we”: of institutional and symbolic orders" (Grunwald, et al., 2023, p. 40). As noted above, behind both kinds of order there is also a political, perhaps better called metapolitical, level of organisation. Strict scientific methods, that exclude the very idea of political intervention, confined to a limited reductionist vocabulary, at some point become an obstacle in their own way. Idhe, referring to the process of purification of science on the way to hermeneutics, cites the periods of first positivism and the subsequent second wave associated with logical positivism and empiricism as one of the stages that made the adoption of the hermeneutics of science most difficult. During this period, science is stripped of its "sense of truth" (Idhe, 1998, p. 143) and focuses entirely on logical formulations and the verification of scientific claims (see also Crease, 1997).

The new step was taken in the studies of Karl Popper, Imre Lakatos, P. Feyerabend and Thomas Kuhn. The latter, according to Idhe, made a radical breakthrough by creating a language that became the language of self-description of science. This is exactly what is implied by the cardinal change of existing hierarchies according to Feenberg. If we follow strictly scientific logic in the spirit of rationalism, language should only serve the existing scientific practice, but in no way become an instrument of its radical transformation. Thus, the change of tradition, the transition to postpositivism, became, in a sense, a hermeneutic revolution. The changed apparatus was followed by a transformation of ideas about symbolic and institutional orders. The development of sociology in the 1970s was the most significant shift of the study of science into the cultural domain. Feminist philosophy of science and standpoint philosophy, as outlined above, radically reconsidered the idea of European rationalism and the dominant universal method as the main obstacle to the diversification of scientific practices.

The issues condemned under the umbrella of technological design could also be called issues of technological engineering. This approach distracts from the issue of technology democratisation. Engineering is an exclusively professional field and “cuts off” the possibility of a broad discussion of technology design issues. Moreover, design is discussed here as the aesthetic antithesis of engineering, not in the sense that engineering does not include the question of aesthetics, but rather focuses on functional efficiency. Admittedly, any embodied technology is considered in the terminology of aesthetics, but its engineering aspects are too specific and professional to be widely discussed in the same framework of discussion as technology design, appealing to the conventionally more accessible notions of ergonomic aesthetics. The democratisation and humanisation of design concerns not only the technical side of the issue, but the changing order of access to social, political and economic institutions. The hermeneutic method applied within science is a way of humanising it, as opposed to the same method applied as a meta-political method, influencing through the impact of the politics of science on other spheres of social life.

Extending the use of the hermeneutic method has the potential to change and broaden first the symbolic and then the institutional order. This implies its democratisation, which Feenberg so actively advocates. It is noteworthy that in considering the prospects for the democratisation and humanisation of technological design, and thus of a number of related social relations, he does not rely on the marginalised as a driving force that is not part of the already established existing system, the mechanisms of which only outwardly appear extremely autonomous. The main similarity between the idea of introducing the hermeneutic method into the analysis of science itself and the considerations of critical theory on the democratisation of science and technology lies in the need for a deep integration of new approaches without relying on outsiders, the marginalised and external factors.

THE RELATIONSHIP BETWEEN THE BASIC PRINCIPLES OF HERMENEUTICS AND THE HUMANIST VERSION OF TECHNORATIONALITY

The principles of hermeneutics can be correlated with the attitudes of the critical theory of technorationality, which is proposed as a solution to the problem of technological and methodological reification. Roughly speaking, the basic principles are the hermeneutic circle, pre-understanding, dialogue and plurality of interpretation. In the critical theory of rationality, the way out of the problem of technological and related social crisis is connected with the identification of the key problem and its solution. These are four main pairs of concepts based on the principle of “problem – solution”: decontextualisation – systematisation; reductionism – mediation; automatisation – vocation; positioning – initiative (Feenberg 1997,1999, 2002). Each of the solutions can be correlated with one of the hermeneutical principles outlined above.

The hermeneutic circle corresponds to secondary instrumentalisation (in other words, systematisation, the introduction of methods and artefacts into broad, multiple contexts). Pre-understanding can be correlated with mediation, the embedding of technological objects in context, taking into account their intrinsic aesthetics and harmony with the environment. The notion of power, both related to and mediated by relationships over technology, has more recently been associated with the notion of care as attuned to maintaining a holistic relationship with the environment (Charolles, Lamy-Rest, 2024). Dialogue in hermeneutics, associated with the reproduction and co-construction of meanings in Feenberg's theory, is shown through the category of vocation, in which subject and object are linked by mutual definition and transformation. The plurality of interpretations is reflected in critical theory through the category of initiative. Here, positioning as an effect of operational autonomy, which only externally separates institutions from the hidden mechanisms of their control, is replaced by initiative, manifested in scientific collegiality, which replaces bureaucracy.

CONCLUSION

The analysis presented here has attempted to explore the underlying reasons that prevent the widespread use of the hermeneutic method in the analysis of science and technology. The main conclusion of the narrative is that its use in science is widespread but carefully hidden. Hermeneutics becomes a method applied at the level of metapolitics, controlling the stability of institutional, especially scientific life, the sociotechnical imaginaries projected to the public, the stability and positivity of notions of rationality, neutrality and autonomy of science. The paradigmatic shift associated with a change in the language of the self-description of science, the study of its institutional mechanisms, revolutionises the scientific narrative. The hermeneutic method, legitimised by the analysis of real scientific practices, radically changes the idea of the normativity of science and the humanity of technology. The hermeneutic approach turns out to be close to the strategy of overcoming technological reification, showing its potential both at the level of solving fundamental scientific problems and at the level of practical technological problems.

REFERENCES

Appadurai, A. (2002). Disjuncture and Difference in the Global Cultural Economy. In X. Inda & R. Rosaldo (Eds.), *The Anthropology of Globalization: A Reader* J. (pp. 46-64). Blackwell.

Charolles V., & Lamy-Rested É. (Eds.) (2024). *Philosophies of Technologies: Theory as Practice.* Wiley. https://doi.org/10.1002/9781394284153

Crease, R. (Ed.) (1997). *Hermeneutics and the Natural Sciences.* Kluwer Academic Publishers.

Feenberg, A. (1997). *Alternative Modernity: The Technical Turn in Philosophy and Social Theory.* University of California Press.

Feenberg, A. (1999). *Questioning Technology.* Routledge.

Feenberg, A. (2002). *Transforming Technology: A Critical Theory Revisited*. Oxford University Press.

Feenberg, A. (2017). *Technosystem: The Social Life of Reason*. Harvard University Press. https://doi.org/10.4159/9780674982109

Grunwald, A., Nordmann, A., & Sand M. (2023). *Hermeneutics, History, And Technology the Call Of The Future.* Routledge. https://doi.org/10.4324/9781003322290

Harding, S. (1988). *Feminism and Methodology.* Indiana University Press.

Harding, S. (2008). *Science from Below: Feminisms, Postcolonialities and Moderities.* Duke University Press.

Harding, S. (2015). *Objectivity & Diversity.* The University of Chicago Press. https://doi.org/10.7208/9780226241531

Idhe, D. (1998). *Expanding Hermeneutics. Visualism in Science.* Northwestern University Press.

Jasanoff S., & Kim, S. (Eds.) (2015). *Dreamscapes of Modernity Sociotechnical Imaginaries and the Fabrication of Power.* The University of Chicago Press.

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Research article

Soft and Hard Hermeneutics of Science and Technologies

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Abstract

The Saqqara Bird, a small wooden figure dated to approximately 200 BCE, has sparked significant debate regarding its purpose and meaning. Initially interpreted by Khalil Messiha as evidence of ancient Egyptian knowledge of aerodynamics, this hypothesis was later refuted, with the figure now widely regarded as a weather vane. Messiha's background as an aeromodeller influenced his interpretation, highlighting the role of personal experience and wishful thinking in shaping historical and scientific narratives. This case serves as a starting point for exploring the relationship between hermeneutics – the interpretation of meanings – and wishful thinking, particularly in the context of science and technology. The distinction between "soft" and "hard" hermeneutics is introduced. Soft hermeneutic practices are aimed to understand different meanings and connections between agents and the world, looking from the side. This distinguishes them from hard hermeneutic efforts which involve self-reflective processes that challenge our personal biases and commitments. Examples from scientific and philosophical contexts, such as Ian Mitroff's study of moon scientists and Nancy Cartwright's concept of "physics as theatre," illustrate how hard hermeneutics can reveal the interplay between personal beliefs and preferences, on the one hand, and scientific practice and the construction of knowledge, on the other hand. Ultimately, hermeneutic efforts, especially in their hard form, encourage deeper self-understanding and critical reflection on the role of knowledge in shaping individual identities.

Keywords: Hermeneutics; Philosophy of Science; Wishful Thinking; Critical Reflection; Rationality; Motivation

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Научная статья

Слабая и сильная герменевтика науки и технологий

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Аннотация

Птица из Саккары – это археологический артефакт, представляющий собой небольшую деревянную фигурку, датируемую примерно 200 г. до н. э. Этот артефакт вызвал серьезные споры среди исследователей относительно его назначения. Первоначально эта фигурка в силу её особой формы была интерпретирована Халилом Мессихой как доказательство наличия у древних египтян знаний в области аэродинамики. Позже эта гипотеза была опровергнута на основании проведенных экспериментов и моделирований. Примечательно при этом, что опыт Мессихи как авиамоделиста, очевидно, повлиял на его интерпретацию данного артефакта, что наглядно иллюстрирует роль личного опыта и склонности агентов порой выдавать желаемое за действительное при формировании своих познавательных установок. Этот случай может служить отправной точкой для изучения взаимосвязи между герменевтикой – интерпретацией значений – и критической рефлексией над склонностью выдавать желаемое за действительное, особенно в контексте науки и технологий. В статье вводится различие между “слабой” и “сильной” герменевтикой. Слабые герменевтические практики направлены на понимание различных значений и связей между агентами и миром при их рассмотрении со стороны. Это отличает их от сильных герменевтических усилий, которые включают в себя процессы саморефлексии, направленные на наши личные предубеждения и обязательства. Примеры из научного и философского контекста, такие как исследование Яна Митроффа об ученых, изучающих Луну, и концепция Нэнси Картрайт “физика как театр”, иллюстрируют, каким образом сильная герменевтика способна раскрыть взаимосвязи между личными убеждениями и предпочтениями с одной стороны и научной практикой и конструированием знаний с другой. В конечном счете, герменевтические усилия, особенно в их жесткой форме, способствуют более глубокому самопониманию и критическому осмыслению роли знаний в формировании индивидуальных идентичностей.

Ключевые слова: Герменевтика; Философия науки; Критическое мышление; Рациональность; Мотивация

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INTRODUCTION

In room 22 of the Egyptian Museum in Cairo there is a small wooden figure called The Saqqara Bird and dated to approximately 200 BCE (Desmond, 2018, p. 5). However, although it is a figure of a bird – it has a head, eyes, nose, body, wings and tail – it definitely is not just a figure. It is something more. Its wings are smooth and flat, its tail is vertical and it has no legs and no feathers. So, it looks like a wooden glider.

Figure 1. The Saqqara Bird

Based on the fact of unusual form of this bird Khalil Messina suggested in 1972 that ancient Egyptians had some knowledge of aerodynamics (Messiha, 1972). Twenty years later he wrote a paper on this topic and called it: "African Experimental Aeronautics: A 2,000-Year-Old Model Glider" (Messiha, 1991). Later, the hypothesis that this figure could be a model of a real glider has been refuted by numerous experiments (Hallion, 2003, p. 11) and simulations (Zierow & Lesemann, 2023, p. 409). Nowadays the most probable explanation is that this figure was used as weather vane.

However, one remarkable fact in this story is that Khalil Messina was a member of the Egyptian Royal Aeromodellers Club, and the Egyptian Aeronautical Club (Abdel-Hamid, 2017). This indicates that his vision and perception of this figure was different from the vision and perception of many people before him. He saw it differently and his experience of aeromodelling influenced him and led to his hypothesis. This hypothesis changed his own view on the history of his land. And at the same time, it was a clear example of wishful thinking which is both quite natural and a flawed type of human reasoning.

In the following sections my aim is to explore in more details the relationship between the notion of hermeneutics of science and technologies on the one hand and the phenomenon of wishful thinking on the other hand. My hypothesis is that analysis of the latter phenomenon plays a crucial role for the former one. I also introduce the distinction between soft and hard hermeneutic efforts.

SOFT AND HARD TOUCHES OF THOUGHT

As Alfred Nordmann says, "how the present connects to the world of the archaeological artefacts is a question of hermeneutics, of telling a story which does not represent 'the past' but constructs this pathway and connection" (Nordmann, 2023, p. 195). Let's call this type of investigation of meanings of things, ideas and theories 'soft hermeneutics.' I call it soft due to the fact that these kinds of hermeneutic practices do not touch us and do not influence us in any significant way. They are not about us. We just try to understand different meanings and connections, looking from the side.

However, far more interesting questions appear when we place ourselves in Messina's position and try to see it from the first person perspective. In that case we may imagine ourselves having some perceptual experience looking at some technical artefact. And based on our imagined previous experience we could feel some inclination to interpret this technical artefact in this or that way, as evidence in favor of some hypothesis about technological knowledge of previous ages. And the hard questions here go as follows. How can we determine whether we are in a position of wishful thinking? How might we estimate the distorting effect of the influence of our past experience? And how could we tell whether we are fair enough in our judgments, or not?

I think that questions of this type could play an important role both in hermeneutics of modern science and hermeneutics of technologies. We can classify these questions as a part of so called 'hard hermeneutics.' This type of hermeneutic effort touches us and can provoke some crucial changes in us and in our self-perception.

I would like to mention two examples here.

The first one is a well-known case study by Ian Mitroff from1969-1972. In this study each of forty-two leading moon scientists was intensively interviewed four times: between the eleventh and twelfth Apollo missions, between the twelfth and fourteenth, between the fourteenth and fifteenth, and between the fifteenth and sixteenth missions. The main goal of the study was quite clear: to explore "the nature and function of the commitment of scientists to their pet hypotheses in the face of possibly disconfirming evidence" (Mitroff, 1974, p. 581) and to examine "the resistance by scientists to the scientific discoveries of other scientists" (Mitroff, 1974, p. 582). There are 260 hours of such recorded interviews where these scientists discuss theories and hypothesis of each other and admit (or not admit) changes in their positions and evaluations in face of new data collected during the period of the study. I submit that this material is exactly what we need to show what hard hermeneutic of science could be.

The results of the study were quite remarkable. There were three scientists among forty-two who were known as the most attached to their pet hypotheses and most resistant to any change. And it turned out that exactly these three scientists were judged by their peers to be the most creative and the most outstanding scientists in the program. So, there was a kind of ambivalence in assessments here.

On the one hand, these three committed scientists were strongly criticized by their colleagues in words such as: "X is so committed to the idea that the moon is Q that you could literally take the moon apart piece by piece, ship it back to Earth, reassemble it in X's backyard and shove the whole thing and X would still continue to believe that the moon is Q. X's belief in Q is unshakeable. He refuses to listen to reason or to evidence. I no longer regard him as a scientist. He's so hopped up on the idea of Q that I think he's unbalanced" (Mitroff, 1974, p. 586); "Y is a good salesman: that's why he gets attention"; "Z tried to put words in the astronauts' mouths; he tried to get them to see what he wanted them to find"; "X has a curious if not perverted pattern of reasoning that goes something as follows. Hypothesis: if the moon were P, then Q would be true; premise: I want Q to be true; conclusion: therefore, P is true"; "X and Y don't do science, they build personal monuments to themselves; I no longer regard them as scientists" (Mitroff, 1974, p. 587).

On the other hand, the same interviewed scientists acknowledged that phenomena of this kind are normal practices in science. They say: "Commitment, even extreme commitment such as bias, has a role to play in science and it can serve science well. Part of the business [of science] is to sift the evidence and to come to the right conclusions, and to do this you must have people who argue for both sides of the evidence. This is the only way in which we can straighten the situation out. I wouldn't like scientists to be without bias since a lot of the sides of the argument would never be presented. We must be emotionally committed to the things we do energetically." "You've got to make a clear distinction between not being objective and cheating. You don't consciously falsify evidence in science but you put less priority on a piece of data that goes against you. No reputable scientist does this consciously but you do it subconsciously." "If you make neutral statements, nobody really listens to you. You have to stick your neck out. The statements you make in public are actually stronger than you believe in. You have to get people to remember that you represent a point of view even if for you it's just a possibility." "In order to be heard you have to overcommit yourself. There's so much stuff if you don't speak out you won't get heard but you can't be too outrageous or you'll get labeled as a crackpot; you have to be just outrageous enough. If you have an idea, you have to pursue it as hard as you can." "Science is an intensely personal enterprise. Every scientific idea needs a personal representative who will defend and nourish that idea so that it doesn't suffer a premature death" (Mitroff, 1974, pp. 588-589).

I think that the intellectual efforts of these scientists during the interviews can be characterized as a hermeneutic process, or at least they serve as a good starting point for a hermeneutic process in its hard form. They tell us here what scientific theories and hypotheses really mean for them. These scientists begin their talks by expressing negative assessments of the behavior of their biased colleagues. However later they make some reflections on this subject and as a result they become willing to admit that such involved and committed strategies may be reasonable forms of behavior in science. And the next step for them could be asking what do they think about themselves in this respect? Do they agree that, to them, their hypotheses mean too much or too little? What role do their scientific efforts play in their lives? Is it just a job for them? Or something more? Why is it important for them that their hypotheses turn out to be true? And what price are they ready to pay for that? Can they say about themselves that they are fair enough in their conduct of science?

On the contrary to Nordmann's position I think that reflections of this type may allow scientists to develop their character, grow as persons and better understand meaning of pieces of scientific knowledge for them. The same is true for philosophers. So, before moving on to the next example I would like to say a few words about the hard hermeneutics of philosophical theories.

First, we should acknowledge that philosophy is not a science. However, philosophy and science are not so different that it is impossible to see some similarities between them (Williamson, 2008). So, doing philosophy we may ask ourselves the same questions as above. When the subject of these questions is not about ourselves but about somebody else then we get some traditional questions for the history of philosophy. Was Plato fair enough arguing in favor of philosophers and criticizing sophists? What did it mean for him to be a philosopher and not a sophist? What price was he ready to pay (and actually payed) for being philosopher? Did he really believe that the ideal state is possible? And did he believe that his description of it really represented an ideal state?

The aim of these questions is to find out what philosophy meant to Plato and what his own philosophical ideas meant to him. As before, we can classify these questions as a part of soft hermeneutics of philosophy. It is an interesting part, but it does not touch us directly. We may discover something about Plato, but it may have no consequences for us.

However, if we address similar questions to ourselves as philosophers then we have a starting point for the hard hermeneutics of philosophy. What is the meaning of philosophy in my life? Am I sufficiently fair in my doing philosophy? Do I really believe in what I am arguing for (cf. Fleisher, 2020)? And if I do, what price am I willing to pay for being right (Plakias, 2019)?

Actually I already tried to answer some of these questions in another place (Frolov, 2019), and I suspect that, for example, my sympathy towards Platonism and abstract objects is closely connected with the fear of losing objects whose existence is finite. And if I argue in favor of moral realism, I do it because I want different states of affairs to be differently significant. I want this difference in value to exist and that's why I try to find arguments to support this theoretical position. And as in Mitroff's case, when moon scientists do not view the existence of personal commitments as a great problem for scientific practice, I also do not think that the existence of my philosophical preferences is a great problem for me. However, these preferences are a suitable subject for my philosophical reflections. And that is exactly what hard hermeneutics of theoretical cognition looks like to me.

PHYSICS AS THEATRE

My second example deals with Nancy Cartwright's idea of "physics as theatre" (Cartwright, 1983) that was also mentioned by Nordmann. The idea goes as follows. Imagine that we write a play for the theatre, and in one scene of this play two characters have a secret conversation in the corner of the room while other characters dance. Then, Cartwright says, "if the actors whisper together, the audience will not be able to hear them. So the other characters must be moved off the stage, and then back on again. But in reality everyone stayed in the same place throughout. We cannot replicate what the characters actually said and did. Nor is it essential that we do so. We need only adhere as closely as possible to the general sense of what was actually said. Physics is like that. It is important that the models we construct allow us to draw the right conclusions about the behavior of the phenomena and their causes. But it is not essential that the models accurately describe everything that actually happens; and in general it will not be possible for them to do so, and for much the same reasons" (Cartwright, 1983, p. 140).

The problem is that once you start doing this, you may eventually forget which parts of your story are true and which are "true lies." And if you lose sight of the boundary between your truths and lies then it becomes difficult for you to control that your lies stay right. In that case everything starts looking right to you, even though some of your lies "cease to be right." When we remove some actors from the scene in our play we act wishfully: we want them to leave the scene and they do it. When we act in the same manner doing science we also act wishfully. Sometimes it is reasonable, sometimes it is not. And it is a hard task to distinguish between these cases.

Asking these questions is a form of hard hermeneutic process in science. It may start with the following questions: what does it mean to be true in science? What does it mean to be right? And what price are we willing to pay for being true (if it is possible) and being right (if being true is not possible)?

It returns us to the question about the attitudes of authors to their scientific texts. It is natural to suppose that there are some general norms that govern the relation between the content of the text and its author. We may call these norms 'assertability conditions.' What are they?

First of all, we may agree with Cartwright and admit that literal truth is not among such conditions. Not everything what we claim in scientific texts needs to be literally true. However, truth is essential to all factive attitudes such as knowledge. So, knowledge that *p* is not among the assertability conditions for asserting that *p* (cf. Williamson, 1996). We may say about some claims in our texts that they are not true and that we know that fact. For example, we may say that pancreas sends some messages to the brain, even though we know that pancreas does not use any language and, presumably, does not possess any intentional states with any intentional content. So, we do not believe and do not know that pancreas sends any messages to the brain. However, having such knowledge is not a necessary condition for assertability of corresponding claim.

The best way to characterize assertability conditions for *p* is to say that these conditions are satisfied if and only if we have some reasons to assert that *p*. These reasons may be different and sometimes we deal with instrumental reasons that allow us to assert some *p* not for the sake of this *p* but for the sake of assertion of *q*. This is the case when we make some true lies. However, we should be very careful here, because doing so it is very easy to stop making reasonable lies and to start asserting unreasonable lies. And I think that this work of being careful can also be characterized as hermeneutic work.

This situation is similar with doing popular science. When we deal with some professional text written in the style of popular science it is useful to make clear distinctions among three types of claims: established scientific knowledge for which there is general consensus among all the specialists; science at the very forefront of discovery where there is considerable room for disagreement among peers; the author's personal view and preferences. We should try to make this distinction as readers, but especially as authors we should try to draw these distinctions as clearly as possible when we write popular science. And I think that these efforts are also a type of hermeneutic process. We try to divide what we know, what we suspect, and what we hope for. Doing so we realize where these boundaries are. And this understanding may influence us and may provoke change in us.

CONCLUSION

One of the crucial metaphors in hermeneutics is the notion of entering. We see something external as a world we can enter into. However, to do this we need to overcome the resistance of this new environment. This resistance is a result of our lack of understanding of this new environment. So, to get deeper we need to understand it better. However, it is not true that for that purpose we need to deal with something external. Sometimes we can get deeper in our own knowledge, theories, and conceptions. We can build them first, and after that we can enter them and see how they are related to other elements of our inner world – our hopes, fears, desires, emotions, and so on. Doing so we better understand what these theories and conceptions mean to us. And at the same time we better understand who we are, how fair we are, and what is the role of knowledge in our lives. It seems to me that all of these issues can be crucial elements of hermeneutic efforts in science.

REFERENCES

Abdel-Hamid, M. A. (2017). Ancient Egyptian Aeroplane Modification. *2nd IUGRC International Undergraduate Research Conference, Military Technical College* (pp. 1–9). Military Technical College.

Cartwright, N. (1983). *How the Laws of Physics Lie*. Oxford University Press.

Desmond, K. (2018). *Electric Airplanes and Drones: A History*. McFarland.

Fleisher, W. (2020). Publishing without (Some) Belief. *Thought: A Journal of Philosophy*, *9*(4), 237-246. https://doi.org/10.1002/tht3.466

Frolov, K. (2019). Why I am a Platonist. *Vox. Philosophical Journal*, *27*, 283-294. https://doi.org/10.24411/2077-6608-2019-00031

Hallion, R. P. (2003). *Taking Flight: Inventing the Aerial Age, from Antiquity Through the First World War*. Oxford University Press.

Messiha, Kh. (1972). Flying in Ancient Egypt. *Egypt Travel Magazine*, *159*, 24–29.

Messiha, Kh. (1991). Aeronautics: African Experimental Aeronautics: A 2000-Year Old Model Glider. In I. van Sertima (Ed.), *Blacks in Science: Ancient and Modern.* (pp. 92–99). Transaction Books.

Mitroff, I. (1974). Norms and Counter-Norms in a Select Group of the Apollo Moon Scientists: A Case Study of the Ambivalence of Scientists. *American Sociological Review*, *39*(4), 579-595. https://doi.org/10.2307/2094423

Nordmann, A. (2023). Machine Hermeneutics. In A. Grunwald, A. Nordmann, and M. Sand (Eds.), *Hermeneutics, History, and Technology. The Call of the Future* (pp. 193–215). Routledge. https://doi.org/10.4324/9781003322290-14

Plakias, A. (2019). Publishing without Belief. *Analysis*, *79*(4), 638–646. https://doi.org/10.1093/analys/anz040
Williamson, T. (1996). Knowing and Asserting. *The Philosophical Review*, *105*(4), 489-523. https://doi.org/10.2307/2998423
Williamson, T. (2008). *The Philosophy of Philosophy*. Wiley-Blackwell.
Zierow, M., Lesemann, L. (2023). Aerodynamic Investigation on the Artefact "Bird of Saqqara". *Acta Mechanica et Automatica*, *17*(3), 405-409. https://doi.org/10.2478/ama-2023-0046

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Research article

Hermeneutics in Research Practice

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Abstract
The article analyzes the role of hermeneutics in science and technology. Hermeneutics involves both an attempt to interpret texts and the fact that the person changes in the process of interpretation. In normal science, hermeneutics plays a secondary role. This is due to the fact that it is built around common ideas that scientists agree with. At the same time, joining a cohort of scientists implies a transformation of the person. Thus, the learning process is associated with the need to use hermeneutic procedures. Analysis of the interaction of interdisciplinary teams shows the importance of forming at least a situational understanding between representatives of different disciplines. Its achievement requires the formation of trading zones. In them, it is possible to achieve mutual understanding, which requires the implementation of hermeneutic procedures. Scientific activity itself requires not only the interpretation of a scientific text, but also practical research activities. Hermeneutics is necessary for the interpretation of research methods presented in scientific texts. It can be based on the use of tacit knowledge. This allows us to show that the use of technical artifacts and technology in general require hermeneutic interpretation. To work with them correctly, it is necessary to master the methods of working with them, their inclusion in our life world. The example of the interface as a technological mediator when working with new information and communication technologies demonstrates that they can construct our ways of perceiving information spaces. In this case, the interface becomes not just a media, but a specific mechanism for constructing the digital world around us.

Keywords: Hermeneutics; Science; Technology; Trading zone; Practice; Technoscience

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Научная статья

Герменевтика в исследовательской практике

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Аннотация:
В статье анализируется роль герменевтики в науке и технике. Герменевтика нацелена как на попытку интерпретировать тексты, так и на изменение субъекта в процессе интерпретации. В нормальной науке герменевтика играет второстепенную роль. Это связано с тем, что она строится вокруг общих идей, с которыми согласны ученые. При этом вхождение в когорту ученых подразумевает трансформацию субъекта. Таким образом процесс обучения связан с необходимостью применять герменевтические процедуры. Анализ взаимодействия междисциплинарных команд показывает важность формирования хотя бы ситуационного взаимопонимания между представителями различных дисциплин. Для этого требуется формирование зон обмена. В них возможно достижение взаимопонимания, которое требует реализации герменевтических процедур. Сама научная деятельность связана не только с интерпретацией научных текстов, но и с практической исследовательской деятельностью. Герменевтика необходима для интерпретации представленных в научных текстах исследовательских методов. Она может базироваться на использовании неявного знания. Это позволяет показать, что использование технических артефактов и технологии в целом требуют герменевтической интерпретации. Для корректной работы с артефактами необходимо освоение способов взаимодействия с ними, их включения в наш жизненный мир. Пример интерфейса как технологического посредника при работе с новыми информационно-коммуникационными технологиями демонстрирует, что они могут конструировать наши способы восприятия информационных пространств. В этом случае интерфейс становится не просто медиа, но специфическим механизмом конструирования цифрового мира вокруг нас.

Ключевые слова: Герменевтика; Наука; Технология; Зоны Обмена; Практика; Технонаука

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INTRODUCTION

The question of applying hermeneutics to the analysis of science and technology is complex and relevant for various disciplines and research projects. It can be related, for example, to the description of the role of hermeneutics in the natural sciences (Heelan, 1998), the analysis different strategy of citizen science (Ottinger, 2017), the analysis of experiment (Wu & Hu, 2023). The use of cognitive strategies of hermeneutics is associated with two key points: a) a change in the subject in the person of getting to know a work of art and b) considering a work of art as a holistic world. “[T]he reader is subject as well as object, agent as well as patient in the hermeneutic process – when I read a literary work, philosophical or legal text, the text happens to me just as much as I happen to the text” (Nordmann, 2023, p. 193). Understanding a work of art requires its deciphering, searching for its meaning. This process turns out to be associated with a change in the person. Hans-Georg Gadamer notes that in order to understand a work of art, it is necessary to have certain cultural prejudices that allow it to be deciphered, a certain cultural horizon with the work of art. “Given the intermediate position in which hermeneutics operates, it follows that its work is not to develop a procedure of understanding, but to clarify the conditions in which understanding takes place. […] The prejudices and fore-meanings that occupy the interpreter's consciousness are not at his free disposal. He cannot separate in advance the productive prejudices that enable understanding from the prejudices that hinder it and lead to misunderstandings” (Gadamer, 2006, p. 295). If these prejudices that form the horizon of understanding are not present, then in order to adequately become familiar with the work, it is necessary to acquire a certain set of knowledge, at least to master the language of the work, which will also require immersion in cultural realities. It is clear that this leads to a change in the person who has decided to enter the world of the work of art. If this horizon exists, then the very acquaintance with the work will add new experience to the person’s existing experience. But can we talk about such experience when we become acquainted with the achievements of science and technology? Is hermeneutic work necessary when mastering scientific texts or working with experimental equipment? Is hermeneutics necessary for working with technology, since most often we can work with it without even understanding its internal structure?

HERMENEUTICS IN SCIENCE PRACTICE

Within the framework of normal science, it is difficult to talk about a “change” in the subject. A scientific article or book that a scientist reads provides him with certain information that he assimilates using the language of science that he has. The terms in it are unambiguous, the relationships between them are described quite transparently, the use of the language of mathematics allows one to avoid inaccuracies in understanding the constructions used. In this case, everything controversial turns out to be associated with solving puzzles. Scientists struggle with them together; when one of them finds a successful solution, the problem ceases to be of interest. It will be solved using well-described methods, a standard and understandable theoretical language. The community of scientists will move on to solving new puzzles. There are no changes in the subject.

He simply learns a new set of facts. The only situation when “acquaintance” with scientific texts can lead to a change in the subject is a scientific revolution. But these revolutionary changes always end with the formation of new normal science (Kuhn, 1962). Therefore, science cannot be considered as a project associated with changing a person in the process of scientific work. It would seem that normal science does not need hermeneutics.

At the same time, it is worth paying attention not only to the immediate work of the scientist with specific scientific texts, but to the very acquisition of scientific knowledge, the processes of socialization in science. Perhaps it is there that one can find the hermeneutic beginning of normal science. Moreover, science itself began, among other things, as a project of “reading” the book of Nature. Acquaintance with science requires not only mastering the language of science, but also the appropriation of the ethos of science, the interiorization of the norms of science, its values and virtues, and the acquisition of scientific practices. Science is not only reading the texts of other authors as the practice of independent research. In this case, acquaintance with scientific knowledge turns out to be associated with a change in the self of a person. For example, Lorraine Daston and Peter Galison, describing the types of objectivity existing in science, distinguish such a type as trained judgment (Daston & Galison, 2010). It requires training from the researcher, as a result of which he will be able to detect objects that he could not distinguish before. For example, only a researcher who has undergone a certain training will be able to say something about the traces of particles in a cloud chamber; a physicist who has not undergone special training will hardly be able to correctly interpret the data. Will mastering this type of objectivity change the moral and ethical ideas of the researcher? Most likely not, but not every work of art is capable of achieving such a result. But, of course, mastering this new practice will change the way the researcher looks at the world; images of objects will appear in it that an untrained person is not able to distinguish. “Instead of the four-eyed sight of truth-to-nature or the blind sight of mechanical objectivity, what was needed was the cultivation of a kind of physiognomic sight – a capacity of both maker and user of atlas images to synthesize, highlight, and grasp relationships in ways that were not reducible to mechanical procedure, as in the recognition of family resemblance” (Daston & Galison, 2010, p. 314). In fact, this learning-cultivation turns out to be the hermeneutic practice that the scientist masters.

From this point of view, the very interpretation of a scientific text is associated with a certain horizon of foreknowledge that its reader has. It includes not only knowledge of the theoretical language of description used in the scientific text, but also an idea of a certain set of practices that its authors can use. This is background, tacit knowledge that is necessary for the correct interpretation of the presented results. The text of a scientific article contains attempts to represent it explicitly in the methods and methodology section, but a correct understanding of this section requires the reader to have tacit knowledge similar to the author. Science is not only reading texts, but also a set of research practices. Getting to know them means overcoming the prejudices that Gadamer wrote about. They allow one to understand the text of an article more adequately and launch a hermeneutic circle that makes it possible to place the text in context and find meaning in it. The difference between a scientific work and a work of art is that an invariant of the meaning of the text can be found in it, which turns out to be unchanged for a large number of specially trained readers. A fiction text can form a different set of answers and meanings, thanks to a larger set of contexts from which it can be considered.

Moreover, if we turn to the analysis of not just normal science, but the functioning of science in modern conditions and describe it as postnormal science (Funtowicz & Ravetz, 1993), science in Mode 2.0 (Nowotny et al., 2003), megascience or even proto-megascience (Pronskikh, 2019) or, in general, as technoscience, we can pay attention to the fact that it often implements complex projects that require the involvement of interdisciplinary teams. In this case, as Galison showed, there is a problem of finding mutual understanding between researchers. For example, the successful solution of problems in the field of radar required the correlation of efforts between specialists in the field of theoretical physics, electrical engineering, circuit design, engineering and other specialties (Galison, 1997). All of them had a general scientific background, but they had undergone specific training related to their specialization. They find themselves in a situation where they need to try to develop a common language to achieve a result. It may not convey quite correctly the complex scientific ideas used by different groups of scientists, but it allows them to find common understanding (Nikiforov & Dorozhkin, 2023). It is formed in specific trading zones of scientific ideas and artifacts. Thus, in the situation of modern interdisciplinary research, the issue of hermeneutic understanding of scientific texts is especially relevant.

The analysis conducted by Harry Collins, Robert Evans and Michael Gorman (2007) shows that the formation of a space of common understanding in trading zones has several development scenarios. A situational unity may form, which is necessary only for solving a specific problem. In this case, after achieving the goal, it will simply disintegrate. But it is also possible to form a new research area. For example, the development of research in the field of lasers would not have been possible without the combined efforts of specialists in the field of technology, theoretical physicists in the field of quantum mechanics, and experimental physicists capable of creating experimental equipment. Thus, Inna Mihailovna Belousova (2014), one of the participants in the work to create the first lasers in the USSR, notes that the prerequisites for the creation of a laser at the S.I. Vavilov State Optical Institute were “deep scientific groundwork in the field of spectroscopy and luminescence of crystals ..., in the field of physical optics and pulsed light sources ..., as well as first-class scientific schools of optical engineering and design ... and active media of lasers” (p. 5). In this case, the formation of a new research area is associated with changes in the structure of scientific knowledge and the emergence of a new, unified type of knowledge and skills among scientists in this field. Science can be associated with the fact that the scientific practice of theoretical research and experimental work itself will require hermeneutic work to understand the results and achievements of colleagues. The text of the article should be divided into semantic parts. Various headings and subheading of the study can be decided by authors. The headings will be depending on the nature of the paper - a quantitative empirical investigation will be structured differently than the critical discussion of a philosophical text.

HERMENEUTICS AND TECHNOLOGY

The appeal to research and experimental practices raises an important question about the use of technology in scientific work. They can also be looked at from the standpoint of hermeneutic analysis. Technical objects, like works of art, are unique worlds that we can enter (Bylieva & Nordmann, 2023). We are able to master them, and they can change us. This characteristic of technical objects turns out to be key to their analysis from the standpoint of hermeneutics. Technology, as Martin Heidegger noted, is closely connected with practical actions, but it originates in the techne of the ancient Greeks, which has not only an applied meaning, but is also connected with poiesis, although modern technology, in his opinion, departs from poiesis (Heidegger, 1977). In this case, technical devices and technologies as a whole are really similar to works of art. After all, a technical artifact is conceived and endowed with a certain function by its author. All technical objects turn out to be specially created artifacts and form their fundamental difference from natural objects. Lynne Rudder Baker (2011) notes: "Unlike natural objects, artefacts have an essence, a nature that depends on mental activity. Technical artefacts depend not only on individual mental activity, but also on social institutions and customs" (p. 62-61). The treatment of technical objects requires a serious system of interpretation of their function and purpose. Incorrect interpretation of such objects can lead to rather strange attempts to reproduce technical artefacts and endow them with functions that are not inherent to them, an example of which can be various cargo cults. In them, technical artefacts, for example, airplanes and runways, are not only recreated in such a way that they cannot perform their functions, because they are made of trees and palm leaves, but also endowed with other functions. It is assumed that they themselves should bring benefits, which with their help are delivered to local residents.

All this indicates that any technical object requires a hermeneutic procedure of understanding it in order to be used. It is associated with recognizing its function and the ways of using it. It is also worth noting that technical objects, and especially instruments of scientific knowledge, exist in two modes: as understandable elements of our life world, the interpretation of whose function occurs almost instantly, and as alien, unfamiliar objects that do not fit into our ordinary life world. Working with the former does not cause difficulties; we may not think about them at all. For example, interpreting the mechanisms of using a knife does not require us to constantly work on deciphering its purpose and the mechanisms of its use. It is simply part of our everyday life world. Perhaps, in some cultures, difficulties will arise with its use. In this case, it will exist as an object outside the usual life world of the bearers of this culture.

Technical devices of the second type, unfamiliar to the life world of some culture, break the automatic circle of hermeneutic interpretation. This is precisely how they reveal an important characteristic of artifacts. They are not only capable of transforming under human influence, changing their function, but also adapt a person to themselves. Thanks to them, unique worlds of the improvised are formed, characteristic of representatives of various social groups. The improvised life world of a nuclear power plant operator differs in many aspects from a similar life world of a peasant. Operators learn for a long time to handle the control panel of a nuclear power plant, read signals from various sensors and displays, and respond to emerging difficulties. They adapt to technical objects and therefore change themselves. The process of learning to handle these artifacts turns out to be associated with the restoration of the automatic passage of the hermeneutic circle of interpreting the function of the artifact. Its restoration will lead to a change in a person. It turns out that a technical artifact, like a work of art, can affect how people position themselves and relate to the world.

This is especially noticeable when analyzing the functioning of new information and communication technologies. It seems to us that their use does not cause us any difficulties, but initially training in interaction with such devices is required. They shape the way we interact with and perceive the digital environments we work with. At the same time, very different digital environments may have dissimilar interfaces. As part of a cursory analysis, it can be noted that, for example, various social networks have similar, but not identical interfaces. This forces us to relearn the mechanisms of working and interacting with them when moving from one to another. It can be noted that in such systems, interfaces act as structures that themselves shape our mechanism of interaction in them. “The interface acts as a structure that allows us to form the user's “lifeworld” and develops his behavioral habits” (Maslanov & Feigelman, 2020, p. 78). In this case, it is quite possible to talk about a hermeneutic analysis of the interfaces of various information and communication environments. They both create mechanisms for working with them and shape our ideas about what is possible in them and what is not. Even simply mastering the interface becomes an important task that changes our very way of existing in the world. It gives us the opportunity to join a new life world that has the properties of intersubjectivity, but is accessible only to those who have undergone a certain procedure of learning-transformation of their own experience. Interfaces turn out to be the most important media. In the case of interfaces, the media is not only a message, but also a mechanism for creating a separate life world.

CONCLUSION

Hermeneutical work is a part of all scientific practice. At the same time, in normal science there is practically no place for hermeneutic work. Scientists of the same discipline understand each other well, have a common and fairly unambiguous terminological vocabulary and methodological approaches to solving problems. They do not need hermeneutic work to understand the texts of their colleagues. At the same time, the very process of entering science turns out to be associated with the hermeneutic procedure of mastering a new and not very well-known culture. After all, one can become a scientist only in the process of mastering scientific knowledge and one's own research activity, which implies the formation of a self with specific characteristics associated with the ethos of science. Therefore, the process of becoming a scientist is a process of self-education, which implies changes in oneself under the influence of mastering scientific texts and practices.

At the same time, scientific practice itself is permeated with procedures of hermeneutic mastering of work with technical objects. It is necessary not only to understand their involvement in research activities, but also to find out how to work with them. These objects themselves form different life worlds of both researchers and ordinary people. A different set of technical tools, especially those that involve mastering different skills for working with them, forms different cognitive skills in people. And if in general it seems to us that there is no hermeneutic work on mastering technology, this is due to the fact that most often we interact with technical tools that have already entered our life world. The technology that is not included in it causes us concern. This is due to the initial lack of understanding of the mechanisms of its use. It is unclear what results can be obtained with its help. Such technology requires us to work hard to understand and master it, to develop skills for working with it, to include it in our life world. And this work may require a revision of ideas about the world not only from an individual, but from all of humanity.

REFERENCES

Baker, L. R. (2011). Ontologicheskaya znachimost' artefaktov [Ontological Significance of Artifacts]. *Epistemology and Philosophy of Science, 2*, 55-63. https://doi.org/10.5840/eps201128227

Belousova, I. M. (2014). Iz istorii sozdaniya lazerov [From the History of Laser Creation]. *Scientific and Technical Journal of Information Technologies, Mechanics and Optics, 14*(2), 1-16.

Bylieva, D. S. & Nordmann, A. (2023). Entering the World Technologically: Early Encounters. *Technologos, 4*, 34-47. https://doi.org/10.15593/perm.kipf/2023.4.03

Collins, H., Evans, R. & Gorman M. (2007) Trading zones and interactional expertise. *Studies in History and Philosophy of Science. Part A. 38*(4), 657-666. https://doi.org/10.1016/j.shpsa.2007.09.003

Daston, L., & Galison, P. (2010). *Objectivity*. Zone Books.

Funtowicz, S.O., & Ravetz, J.R. (1993). Science for the post-normal age. *Futures, 25*(7), 739-755. https://doi.org/10.1016/0016-3287(93)90022-L

Gadamer, H.-G. (2006). *Truth and Method*. Continuum.

Galison, P. (1997) *Image and Logic. A Material Culture of Microphysics*. The University of Chicago Press.

Heelan P. A. (1998). The scope of hermeneutics in natural science. *Studies in History and Philosophy of Science. Part A, 29*(2), 273-298. https://doi.org/10.1016/S0039-3681(98)00002-8

Heidegger, M. (1977). *The Question Concerning Technology and Other Essays*. Garland Publishing.

Kuhn, T. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.

Maslanov, E. V., & Feigelman, A. M. (2020). Neyavnoye znaniye v internet-kommunikatsii: interfeys kak mekhanizm proizvodstva neyavnogo znaniya [Tacit Knowledge in Internet Communication: Interface as a Machine for Tacit Knowledge Production]. *Vestnik Tomskogo gosudarstvennogo universiteta – Tomsk State University Journal, 460*, 77–83. http://dx.doi.org/10.17223/15617793/460/9

Nikiforov, A. L. & Dorozhkin, A. M. (2023). Trokhmernyy obraz nauki i zony obmena P. Galisona [Three-component Image of Science and Trading Zones of P. Galison]. *The Digital Scholar: Philosopher's Lab*, *6*(2), 6-18.

Nordmann, A. (2023). Machine Hermeneutics. In A. Grunwald, A. Nordmann & M. Sand (Eds.) *Hermeneutics of Science and Technology* (pp. 193-215). Routledge. https://doi.org/10.4324/9781003322290-14

Nowotny, H., Scott P., & Gibons, M. (2003). Introduction: 'Mode 2' Revisited: The New Production of Knowledge. *Minerva*, *41*(3), 179-194. https://doi.org/10.1023/A:1025505528250

Ottinger G. (2017). Making sense of citizen science: Stories as a hermeneutic resource. *Energy Research & Social Science*. *31*, 41-49. https://doi.org/10.1016/j.erss.2017.06.014

Pronskikh, V. (2019). Proto-Megascience. Perevod interesov v zone obmena [Proto-Megascience: Translating Interests in a Trading Zone]. *The Digital Scholar: Philosopher's Lab*, *2*(2), 16-28.

Wu, G. & Hu M. (2023). Hermeneutical Analysis of Scientific Experiments. *Technology and Language*, *4*(1), 17-30. https://doi.org/10.48417/technolang.2023.01.02

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Research article

A Call for Technological Understanding

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Abstract

The daily experience of multistabilities of technical artefacts gives rise to the question of how we can make sense of them in the interaction. A historical and ontological review reveals that technology provides a more primordial way of knowing than science. A comparison between explanation and understanding in science demonstrates that a scientific explanation alone is insufficient for the acquisition of all knowledge. Achieving scientific understanding requires a confluence of a scientific explanation, human agency and social context. Having emerged as a key issue within the engineering-oriented philosophy of technology, the shared consensus of researches on technological explanation is that deductive reasoning is insufficient for producing a comprehensive explanation of function in terms of physical structure. Based on the pervious discussions, I introduce the notion "technological understanding" referring to sense-making in the interaction with technical artefacts in this paper. This understanding is unfixed and involves primitive, context-sensitive, re-interpretative and history-situated sense-making. A theory of technological understanding as a comprehensive exploration of human cognition should take all the conditions and factors of understanding into account. A preliminary analysis indicates that the affordances of a technical artefact, context and human agency are essential components for the technological understanding. In addition, the acknowledgement of and concern with sense-making of situated, context-sensitive meanings align with the core of hermeneutics. Therefore, taking hermeneutics of technology into account may provide productive insights for exploring technological understanding.

Keywords: Technological Understanding; Technological Explanation; Multistabilities of Technical Artefacts; Hermeneutics of Technology; Engineering design

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Научная статья

Призыв к технологическому пониманию

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Аннотация
Повседневный опыт мультистабильности технических артефактов порождает вопрос о том, как мы можем осмыслить их во взаимодействии. Исторический и онтологический обзор показывает, что технология обеспечивает более исконный способ познания, чем наука. Сравнение объяснения и понимания в науке показывает, что одного научного объяснения недостаточно для приобретения всего знания. Достижение научного понимания требует слияния научного объяснения, человеческого фактора и социального контекста. Возникнув как ключевой вопрос в инженерно-ориентированной философии технологии, общий консенсус исследователей технологического объяснения заключается в том, что дедуктивное рассуждение недостаточно для создания всеобъемлющего объяснения функции с точки зрения физической структуры. Основываясь на предыдущих обсуждениях, я ввожу понятие "технологическое понимание", относящееся к созданию смысла во взаимодействии с техническими артефактами в этой статье. Это понимание не фиксировано и включает примитивное, контекстно-зависимое, реинтерпретационное и исторически обусловленное создание смысла. Теория технологического понимания как всеобъемлющее исследование человеческого познания должна учитывать все условия и факторы понимания. Предварительный анализ показывает, что возможности технического артефакта, контекста и человеческого фактора являются существенными компонентами для технологического понимания. Кроме того, признание и озабоченность смыслообразованием ситуативных, контекстно-зависимых значений согласуются с ядром герменевтики. Таким образом, учет герменевтики технологий может обеспечить продуктивные идеи для изучения технологического понимания.

Ключевые слова: Технологическое понимание; Технологическое объяснение; Мультистабильность технических артефактов; Герменевтика технологий; Инженерное проектирование

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INTRODUCTION

This may be a shared experience of the multistabilities of a single piece of artefact: when we sit on the floor, a chair can turn into a table; or the handles of a treadmill can do excellent work as clothes hangers. Numerous comparable examples can be found within broader cultural contexts as well: an Indian prayer wheel is transformed into a windmill in Western culture, and sardine cans are worn as fashionable decorations among the New Guineans. The usage and impact of a given product may vary significantly across different social and cultural environments. This "ambiguity of technology" has been considered cultural hermeneutics by Don Ihde (1990). It raises the question of which forces contribute to the transformation of purpose or utility.

Chair, treadmill, and prayer wheel are all technical artefacts. They are products from technological industries and material embodiments of technology. Given the importance of technology and technical artefacts in modern societies, it would be unimaginable to live in a world without them. Therefore, the scenario outlined above is a recurring phenomenon in our daily lives. In effect, it is an issue concerning understanding. If the different ways of grasping and using the same technical artefact should not be viewed as totally arbitrary, which factors affect our understanding of these technologies? If there are none too many accounts of "technological understanding," however, this may owe to the long-standing neglect of technology when it was classified for a long time as subordinate to science and scientific understanding.

This paper is a call for increased attention to the conception of "technological understanding." It proceeds in three steps: first, a justification for technology as a primordial way of knowing; second, an analysis and comparison of explanation and understanding in science as a backdrop for the following investigation; third, a call for accounts of technological understanding in contrast to technological explanation, with a preliminary review and exploration of the factors that are relevant for their comparison.

TECHNOLOGY: A MORE PRIMORDIAL WAY OF KNOWING

Speaking of technology, people immediately associate it with science. The phrase "science and technology" with the connection and hierarchy embedded are so deeply ingrained in people's minds, that it seems as they two are born together as a big brother "science" and the little brother "technology."

The motto attributed to Francis Bacon, "Scientia potentia est" ("Knowledge is power"), reflects the recognition of modern science and the desire in Western thought to harness its power and gain mastery of nature. Science is viewed as an objective approach to discover true knowledge about nature. Scientists work in their laboratories, making experiments and creating mathematical simulations to deliver explanations of natural phenomena and establish laws of nature. Modern science establishes a clear dichotomy between the observer (human) and the observed (object), seeking to eliminate all human factors, purifying and reducing experiences in our lifeworld to formal and mathematical terms. It is a structural description of the real world. From this perspective, scientific knowledge is conceived as entirely pure and objective, devoid of any social or human influence.

It is undeniable that natural science has achieved remarkable success and has indeed made significant contributions to the development of humankind. This success, in turn, consolidates the noble status of science and draws many advocates. Scientism and related perspectives such as positivism and scientific realism wholeheartedly endorse science. Scientism privileges science as the most valuable source of insight and learning which can uncover the truth behind the phenomena (Sorell, 2013). This science-centric trend has also influenced disciplines like sociology. These often adopt quantitative methods such as quantitative analysis in an effort to establish themselves as a science. Likewise, positivism is a philosophical school that regards scientific verification as the foundation of all knowledge.

When our analysis turns to technology, we will see that its conceptual status remains unsettled. Normally, technology is viewed as a derivative of science. Gardner summarized this position as "technology-as-applied-science (TAS)." It is "the idea that technological innovations can be seen as the application and practical embodiment of ideas first gained through scientific research" (Gardner, 1994, p. 133). Bacon is often taken as an early proponent of TAS, because he believes that science can facilitate the development of technology. He places a high value on the immense power of technology for human to take mastery over nature: "the true and lawful goal of the sciences is none other than this: that human life be endowed with new discoveries and power" (Bacon, 1620/2000, p 66). Mario Bunge is another famous representative of TAS. He supports the distinction between pure science and applied science, and identifies technology with applied science. For him, the pure cognitive pursuit will aim toward pure science, while a fundamentally practice-oriented goal gives rise to applied science (Bunge, 1966).[1] Science provides the theoretical part and technology the practical; science strives for eternal truth while technology is to solve problems. It is that "scientific ideas have been the main motor and technology their beneficiary" (Bunge, 1966, p. 330). The TAS idea illuminates the dependence of technology on science. The scenario is that stable knowledge comes from scientific research and then technology takes advantage of it. In this case, technology is not only entangled with science but also takes a subsidiary role within a hierarchical order that assigns primacy to science.

Even though TAS has long been dominant and remains highly influential to this day, other thinkers have taken different positions. It is readily apparent that the manipulation of tools dates back to the very beginning of human existence. The basis of human's survival consists in the ability to cope with various obstacles we confront in the natural environment (Lindberg, 2010). In order to survive we need to create conditions for ourselves by making use of the resources we can find. All those necessary activities and creations for living have finally grown to crafts, techniques, and eventually to contemporary highly advanced technology. The history of using and producing tools of "homo faber" is much longer than the doing of science which has a history of only 3000 years (Niiniluoto, 2016). Based on statistical methods, Derek de Solla Price drew the

[1] According to Carl Mitcham, Bunge's paper with the title "Toward a Philosophy of Technology" was the first time that the phrase "philosophy of technology" came to the fore in English (Mitcham, 1994, pp. 36-37). However, Bunge only views technological knowledge as "an outcome of the application of the method of science to practical problems" (Bunge, 1966, p. 331).

conclusion that science and technology have separate structures and independent patterns of cumulation in their knowledge development (de Solla Price, 1965). There is in this picture no direct flow of impact in both directions except in some special and unsettling cases like what Thomas Kuhn calls paradigm shifts (Kuhn, 1997). Thus, it is wrong to see technologies as applications of scientific discoveries. From researches in history of science, Kuhn observes that "(s)cience and technology had been separate enterprises before Bacon announced their marriage in the beginning of the seventeenth century, and they continued separate for almost three centuries more" (Kuhn, 1971, p. 284). Many technological innovations are independent of and even prior to science. This holds not only in Western contexts. Song Yingxing, a Chinese scholar in the Song Dynasty, held that cosmological knowledge and universal principles are embedded in the processes of everyday crafting and technique. His book *Tiangong kaiwu* sets out to demonstrate how this knowledge functions as models that guide how people should behave themselves (Song, 2011). This systematic search "for a rational order in the world" aligns with the modern conception of a natural scientist (Schäfer, 2019, p. 54). Though coming from various backgrounds, these thinkers articulate a shared view from the historical aspect that doing technology can produce its own knowledge which is independent of doing science (also, for example, Arthur, 2009; Layton, 1974; Mitcham, 1994; Vincenti, 1990).

Heidegger's (1927/1962) analysis makes him a representative for an ontological defense of the primacy of technology. In his early work *Being and Time*, his examination of ready-to-hand (*zuhanden*) and present-at-hand (*vorhanden*) entities reveals that in manipulating technical apparatus there exists a primordial mode of knowing. This kind of knowing is not a theoretical cognitive process, it is the initial grasping of the living and "furry" reality through using, producing, and manipulating – far before a theoretical thematization of the world. It is an engaged, pre-scientific, and existential form of knowing. In *The Question Concerning Technology*, Heidegger (1977) defines technology as a mode of revealing, a bringing-forth (*poiesīs*) that "brings out of concealment into unconcealment", a realm in which truth is disclosed (p. 308). He is among a group of philosophers who assert the opposite: Modern science is based on modern technology, as the development of science relies on the state of technology (see, for example, Arthur, 2009; Heidegger, 1977; Ihde, 2010). The reason why modern technology no longer serves as a bringing-forth, but rather as enframing (*Gestell*) is that modern technology no longer reveals things in the mode of bringing-forth. In the contrast, it challenges nature and humankind into standing reserves. "Seeing" through the lens of modern technology provides modern science with "calculative thinking." All the living and furry flesh of reality is wiped away after this process, only the results of calculation remain. Combining Heidegger's ontological analysis and Lynn White's historical insights, Don Ihde (2010) articulates the claim that "the historical-ontological priority of technology as a condition of the possibility of science" (p.57).

In light of the above discussions, I would maintain that doing technology is actually a more primordial way of knowing the world than doing science. Science is viewed as a systematic pursuit of knowledge, is an abstract thematization, a mathematization of the real world. It displaces the phenomenal world by mathematical models that are to observe and handle. Scientific practice abstracts formal models from the richness of the empirical world, reducing living materials such as soil and leaves into numbers and statistical tables (Latour, 1999). Through that, the natural phenomenon is mathematized, calculated, mimicked and manipulated, the lifeworld in which we live in with all the living entities disappears, while a purely scientific world is constructed. This differs from how we interact with technical artefacts. We do not mathematize the artefacts when we use a tool, only manipulate and experience them with our bodies and limbs. Although we sometimes require mathematized information such as the precise size of a hammer, this information emerges from and ultimately serves our lived experience.

What we know and how we understand technology from these primordial experiences thus becomes a topic to talk about. A related issue can be found in the discussions of explanation and understanding in science. Although knowledge acquisition in science and technology cannot be equated, the problem of “scientific understanding” echoes and foreshadows the difficulties of technological understanding.

SCIENTIFIC UNDERSTANDING: A COMPREHENSIVE ACCOUNT OF THE COGNITIVE PROCESS

Not content with merely knowing natural phenomena such as the sun rising in the morning and setting in the dusk; one wants to know why it happens. We call both forms of knowledge scientific: know-that which is descriptive and know-why which is explanatory. Philosophers have been endeavoring to offer definitions and criteria for scientific explanations. A consensus is that, scientific explanations go beyond merely describing phenomena as they intend to answer the why-questions. And in the spirit of logical empiricism: they should not exceed the empirical sphere. Among a series of accounts, the best-known canonical account is the deductive-nomological (DN) model introduced by Carl Hempel and Paul Oppenheim, which serves as the starting-point for contemporary discussions of scientific explanation.

In recent decades, a group of philosophers began discussing scientific understanding. It is not that the term “understanding” never appeared in earlier discussions. Since the beginning, it has been held that scientific explanations foster an understanding of scientific phenomena (for example, Friedman, 1974; Salmon, 1990). That is to say, understanding is the result of scientific explanations. Through correct scientific explanations, we are able to understand how nature works, why the sun rises at dawn and sets at dusk. However, given that scientific knowledge is held to be objective and devoid of any personal quality, explanation’s close association with logical inference places it in alignment with the spirit of science. By contrast, understanding is associated with human, with a psychological and subjective nature. It is widely suspected of lacking epistemic weight and has been overlooked in the philosophy of science.

As of late, the concept “scientific understanding” has attracted increasing attention. The proponents contend that scientific understanding is more than knowledge acquired through scientific explanation. Henk de Regt insists that scientific understanding requires not only knowledge but also the skills of the scientists and the intelligibility of theories (de Regt & Dieks, 2005; de Regt, 2009, 2022). He establishes a model of understanding phenomena, arguing that “pragmatic understanding of theories (UT, intelligibility) is a necessary condition for understanding phenomena (UP)" (de Regt, 2009, pp. 37-38). It is context-dependent, subject-dependent and epistemically relevant. Peter Lipton (2009) highlights the important role of good judgements and tacit knowledge besides theoretical knowledge. Also, he is among those who deny the necessity of scientific explanation for purposes of understanding. He argues that explanation is not necessarily required for understanding, as knowledge may be acquired through other means. In other words, this would be an instance of "understanding without explanation." Johannes Lenhard (2009) exemplifies this by offering an example of computational simulation which empowers scientists to control and predict systems without mastering the theory. Simulation takes the place of theory-based knowledge in its conventional role, giving rise to a phenomenon that may be described as an epistemic black box, and yet it may provide understanding. Meanwhile, there remain philosophers who reject the epistemic status of understanding. J. D. Trout (2002) holds the view that, only explanations and theories that aspire to be true can benefit the development of science, whereas the mere enlightened feeling of understanding something, possibly in light of a false theory or explanation, is subjective and epistemically unrelated. Kareem Khalifa (2012) suggests that the notion of "scientific understanding" solely provides a "repackaging" of explanation in the arguments put forward by proponents.

The central issue that needs to be addressed here is how is explanation and understanding connected? Is "scientific explanation" a necessary and sufficient condition for "scientific understanding," or at least necessary, or neither sufficient nor necessary? If scientific explanation is both necessary and sufficient for scientific understanding, any further consideration of the latter appears superfluous. If there are instances of scientific understanding in the absence of a scientific explanation, then the latter cannot be considered a necessary condition for the former.

I argue that "scientific understanding" deserves careful consideration, yet I would not go so far as to propose that it does not presuppose scientific explanation as a necessary condition. A scientific explanation always introduces a theoretical component. In contemporary scenarios of automation, new computational technologies have come to replace the role of scientists in the process of explanation. It is, however, only the one who explains changes, not the explanation itself disappears in understanding. This de-skilling has long been a trend in scientific and technological development. Analogous to the use of packages in programming, where the underlying principles are enclosed in the package, it can foster the effectivity in research and development. Manipulators do not need to know the mechanism, which facilitates a quicker entry for those from interdisciplinary backgrounds.

However, scientific explanation alone is insufficient to bring about understanding. The two are not equivalent, because a bare theory standing there will not make any contribution, it needs to be grasped by scientific practitioners. An explanation explains a theory successfully only when it is received correctly. "Skills," "judgements," "good sense," and "tacit knowledge" are necessary to the activity of understanding, making sure that explanation can work properly. Gerhard Schurz and Karel Lambert asserts that to understand is to be able to fit a phenomenon into the cognitive corpus of an agent (Schurz & Lambert,1994, pp. 66). If a theory which explains natural phenomena does not fit into our cognitive frame of reference or background knowledge, it has no epistemic value. This is, in fact, a common principle in the field of education: when designing teaching content for children, educators must adapt both the content and its level of complexity to suit their developmental levels and needs. This often involves simplifying the content to ensure it is comprehensible for children.

As with typical application questions that we confront in school, it is generally the case to handle questions in concrete scenario. Patrick Heelan (1998) distinguishes between two layers of meaning when one needs to explain scientifically – a theory-laden meaning and a cultural praxis-laden meaning. These are “merely co-ordinated but not isomorphic.” Invoking Heidegger’s example of a hammer, Heelan argues that, in order to explain what a hammer is, one must first clarify that it is used for a construction project – this constitutes the cultural and practical part of the meaning of a hammer. In addition, it is necessary to address the theoretical component of the hammer, which includes its specification and functional properties for a construction project. Only the two layers together can make up the whole picture of a hammer. Without knowing the cultural-practical condition, the concept of hammer remains abstract and intangible, making it impossible for us to gain a complete picture of the hammer. The attempt to identify explanations in every new context is already hermeneutical (Heelan & Schulkin, 1998).

The analysis above suggests that “scientific understanding” introduces new issues and questions that call for deeper exploration. Scientific understanding involves a holistic, integrated, and synthetic cognitive practice, it is a form of sense-making, a context-sensitive endeavor. It emerges from at least the co-action of a scientific explanation, the human agent who attempts to understand the natural phenomenon, as well as a certain context, in which understanding takes place and that gives rise to scientific understanding. To explore this human practice, we cannot just focus on a small zoomed-in zone of explanation to thereby neglect the whole picture of understanding.

CALL FOR TECHNOLOGICAL UNDERSTANDING

After the preliminary consideration of technology and the need to achieve understanding of technical artefacts, and after a review of discussions of explanation and understanding in science, we can now venture towards the question of technological understanding.

Technical artefacts and the empirical turn

Our everyday contact with technology is, in most cases, interaction with technical artefacts.[2] Technical artefacts are situated within the category of artefacts, products of technological processes. Conventionally, artefacts are defined as unnatural, mind-

[2] I will not distinguish between “technical” and “technological” in this article, even though one would see more clearly the interrelation between technology and society that is entailed by the term “technological”. Since, along with technical products, everything technical interacts with social factors, making this distinction between these two terms would require extra effort and little benefit. For the artefacts designed and manufactured by technological industries, I will use the common term “technical artefacts.” With the development of technology, novel forms of technology definitely emerge. This article focuses exclusively on technological products with a material dimension.

dependent, intentionally made objects for realizing particular purpose (Hilpinen, 1992; Baker, 2004; Preston, 2022).

Analogous to the differing views of science and technology, we can also observe contrasting attitudes toward natural substances and artefacts. This can be traced back to ancient Greece. In his *Nicomachean Ethics*, Aristotle distinguishes between natural and artificial objects in terms of the "first principle," and this distinction is accompanied by a clearly articulated hierarchy. While natural substances are considered to be "things that are or come into being by necessity," their existence does not rely on human will, "they have their first principle within themselves." Technical products, on the other hand, don't have their "first principle," they are human-made, mind-dependent, and it is the producer who brings them into being (Aristotle, 2000, p. 106). In this sense, artefacts are inferior to natural substances which exist necessarily in the world. The marginalization of artefacts has resulted in the prolonged absence of artefact and materiality in metaphysics. Some philosophers even claim that "artifacts such as ships, houses, hammers, and so forth, do not really exist" (Hoffman & Rosenkrantz, 1997, quoted in Baker, 2007). Till now, the ontology of artefacts remains a challenging question.

Technology and technical artefacts have finally reached a turning point in terms of their recognition, due in large part to the empirical turn in philosophy of technology. A group of philosophers began to focus on the material dimension of technologies. According to Philip Brey (2010), the empirical turn comprises two different approaches: the society-oriented and the engineering-oriented approach. The society-oriented approach seeks to analyze the influence of technologies on humans and society. As one of the most representative philosophers, Ihde (1990; 2009) is known for his contribution of technologically mediated perception and material hermeneutics. Other notable figures include Bruno Latour, Donna Haraway, and Peter-Paul Verbeek. On the other side, the engineering-oriented approach focuses on the technological practice and systems or devices themselves rather than their impact. Carl Mitcham (1994) is considered among the earliest scholars to call for a refocus on technology itself. He advocates active dialogues between philosophers of technology and engineers. Heeding his call is a group of philosophers including Joseph Pitt, Peter Kroes, Anthonie Meijers, Pieter Vermaas, and Wybo Houkes.

Despite taking different directions, they nonetheless share common ground and can benefit from each other to some extent. Unlike classical philosophy of technology, both approaches no longer restrict the focus on metaphysical and transcendental conditions of technology. Technology is treated not only as an unreducible abstract notion. Rather, analyses are concrete and empirical, turning to more specific and detailed modern technologies and focusing on human experience. Another notable commonality lies in the fact that both approaches emphasize description rather than evaluation. Philosophical reflection of technology "should be based on empirically adequate descriptions of technological practices and technical artefacts" (Meijers, 2000, p. 93). The trend turns from the classical normative and evaluative philosophies of technology towards empirical and descriptive ones (Brey, 2010; Franssen et al., 2016).

Discussions on technological explanation

"Technical artefacts" are of central concern to the engineering-oriented philosophers. Kroes and Meijer's proposal regarding "the dual nature of technical artefacts" created a new framework for research (Kroes, 1998; 2006; 2010; Kroes & Meijers, 2006). They define technological artefacts as "(i) designed physical structures, which realize (ii) functions, which refer to human intentionality" (Kroes & Meijers, 2006, p. 2). In this sense, technical artefacts have on the one hand physical structures that allow them to realize their function, on the other hand, they are intentionally created to realize a certain function, they are inscribed with a "for-ness", i.e. a teleological element. Both are indispensable; neither the physical structure nor intentions alone are sufficient to constitute a technical artefact. And yet it does not provide an ontology of technical artefacts. The theory of dual nature does not deliver an account of the essences of technical artefacts is (Houkes et al., 2011). Instead, it offers conceptualizations from two different perspectives from which we can read artefacts in terms of the tension between designing and using.

Following this direction, we will soon confront two familiar philosophical themes. Since technical artefacts have two conceptualizations from physical and intentional perspectives, how are these related? It is in fact a mind-body problem (Kroes & Meijer, 2006). The notion of "function" seems well-suited to bridge the two poles, since from one perspective the designed physical structures are to realize functions, and functions, from the other perspective, refer to human intentionality. In order to bridge the gap, Vermaas and Houkes with their research group introduced the ICE-theory on technical functions and analyzed the "use plans" in different cases of designing and using (Houkes et al., 2002; Vermaas & Houkes, 2006). By incorporating the notion of function, one finally arrives at a tripartite model of the conception of a technical artefact. It involves a physical structure, a technical function, and a context of intentional human action (Kroes, 2010).

Even prior to the emergence of the dual nature project, Kroes (1998) had introduced a pair of terms – technological explanation and functional explanation – in portraying the relation between structure and function of technical artefacts. [3] While functional explanation is invoked where function explains structure, a technological explanation serves to explain how a physical structure can realize the function:

> A design also contains (at least implicitly) an explanation of how the proposed physical system will be able to perform the required function. In other words, a design also consists of a technological explanation, i.e., an explanation of the function of a technological object in terms of the physical structure of that object. A technological explanation is an integral part of a design and plays a crucial role in justifying a design: it shows that on the basis of its physical structure an object will perform a certain function. (Kroes, 1998, p. 125)

[3] Kroes used the term "technological objects" in an early paper on "Technological explanations: the relation between structure and function of technological objects", whereas "technical artefacts" in later writings. Since there is no obvious difference between them, I will use "technical artefacts" to indicate both terms in Kroes's writings to ensure terminological consistency across this paper.

Kroes also differentiates technological explanation from physical explanation: Whereas the former explains the function of an artefact, the latter explains how the structural composition will result in a physical movement.

From daily activities, it is plausible that the physical structure and the function of a technical artefact are closely related. Function is realized through a specific physical structure. This relationship distinguishes technical artefacts from social objects whose function is based on collective intentionality (Kroes, 2010). However, a logical gap exists between structural and functional descriptions. As different structures can realize the same function, and a structure can conversely realize multiple functions, the inference does not work in both directions. A technological explanation is thus not a deductive explanation, it cannot be fitted into the DN-model. Kroes also points out that the "for-ness" of a technical artefact involves a normative dimension. In this sense, the coherence between functional and structural descriptions turns out to be an is-ought problem: how a technical artefact ought to function cannot be derived from what the structure is. Addressing this question requires more than purely deductive relations. Given that technical function is action-oriented, practical reasoning needs to be inclusive in order to bring the perspective of intentionality into consideration (Kroes, 2006). A similar observation has been made by philosophers from the society-oriented approach. It aligns with what Ihde(1990) calls the "ambiguity of technology".

Jeroen de Ridder (2007) criticizes Kroes for attempting to explain the function of technical artifacts solely through the analysis of the physicochemical structure. The reason is that the function and physical structure of an artefact are actually not directly connected. His proposal is a combination of two independent but related theories – a function theory which "explicates the conditions under which an intended behavior is the artifact's function" and an artifact explanation which "explains how the artifact is able, in virtue of its physicochemical structure, to show this behavior" (de Ridder, 2007, p. 215). He explicitly points out that the function of a technical artefact cannot be considered in isolation without context such as its ecological niche, its history, designers, users, as well as their intentions and beliefs.

Joseph Pitt insists on the priority of epistemological issues, claiming that we cannot conduct fair and reliable assessments regarding the impact of technology unless we understand "how we know that what we know is reliable" (Pitt, 2000, p. viii). Compared to scientific explanation, Pitt attributes a greater number of tasks to technological explanation: to explain what makes a technical artefact what it is, to explain its role in society, to explain technological failures and attribute responsibility (Pitt, 2009). The search for universality in scientific explanation cannot be meaningfully applied to technological explanation, as what is mainly at stake in technological explanation are the human-made technical artefacts. An artefact-specific explanation is not satisfying and exhaustive. Since no single aspect of an artefact can be explained in an isolated sense, he argues that all the factors in a technological explanation require an appeal to systems, which is essential to being able to offer or understand a technological explanation. For example, sometimes a deeper insight into the electric grid and even historical factors will be needed to answer the question "Why did that light bulb turn on?" In addition, the answer will vary depending on the interest and purpose of the question – who raises it and why – and on how much depth and detail is expected by the audience. Someone may only expect an answer like “Because the switch was flipped.” One needs to identify in these instances exactly what the question is, adjusting the answer accordingly (Pitt, 2009).

The various authors who join in these efforts agree that deductive reasoning is insufficient for a satisfying explanation of technical function because a deductive reasoning does not move smoothly between two poles. A technological explanation should go beyond a pure deduction and must involve something practical and social. Notably, Pitt expands the scope of technological explanation beyond its definition and differentiation by Kroes. For Kroes, a technological explanation is intended to explain and justify the design of a technical artefact. Even though it seems to require practical reasoning, the goal remains restricted to an argument about the technical artefact itself. In the contrast, Pitt takes into consideration the context of explanation. He attaches more importance to the question of what and how an audience wants to understand a technical artefact.

Necessity of technological understanding and a hermeneutics of technology

I would argue that what Pitt seeks to do goes beyond a theory of technological explanation and touches on that of technological understanding. What I call for is a philosophical exploration of technological understanding. In order not to get confused, we need to distinguish these two notions before further investigation.

Coming from the widely recognized difference between explanation and understanding, as discussed in previous sections, I would borrow the definition of technological explanation from Kroes and make a small revision. A technological explanation is an explanation of the possibility of potential functions that a technical artefact can realize, based on the physical structure and presupposed usage scenario. In many cases, it is not a fixed answer. It is more than an artefact explanation as proposed by de Ridder which is dedicated to offer information about what this structure can provide and why estimated functions can be realized. This explanation is not a deduction, but synthetic reasoning for engineering design. It can function as a justification of design, and also act as a theoretical foundation and guideline for engineering design.

By technological understanding, I refer to the way in which we make sense of our interactions with technical artefacts. A philosophical reflection on technological understanding concerns the conditions for this sense-making. It is a holistic and synthetic investigation of how we learn to know technology, taking into consideration the context and human agents who interact with the technical artefacts. This does not differ much from what Pitt advocates for within the notion of “technological explanation.” In this regard, an analysis of technological understanding provides the insight from a user's perspective, which can play a supportive role in technology assessment and the improvement of engineering design.

Whereas scientific understanding usually occurs in specific academic contexts, technological understanding occurs more frequently. It takes place not only among engineering designers in academic fields, but in our mundane daily life; not only when we encounter a new product, but all the time we interact with technical artefacts. We perceive, understand, and use the technical artefacts based on specific conditions in every interaction. Even tools that are ubiquitous in everyday life can take on new purposes when situated in a different context. The meaning of a technical artefact may vary from person to person, from time to time, from scenario to scenario. This unfixed, situated and context-sensitive characteristic of technological understanding highlights why it is difficult to deal with the ontological issues of technical artefacts.

Scientific understanding is attributed to a confluence of human agent, theoretical scientific explanation, and the specific context, although the function of scientific explanation is sometimes carried out by computational technologies instead of scientists. What is the analogous situation in the case of technological understanding? As previously stated, technology is a primordial way of knowing. For most lay people, when we interact with technical artefacts without instructions, we rarely mathematize and theorize them, instead, we perceive and manipulate them directly. I intend to borrow the term "affordance" to describe what technical artefacts provide human agents. "Affordance" is a concept introduced by James Gibson in ecological psychology, referring to what the environment can offer and furnish (Gibson, 1979). This notion emphasizes a direct perception, it is primitive sense-making. For example, a flat platform affords support, a handle affords to be gripped. Later, this concept is borrowed by Madeleine Akrich, Bruno Latour and Don Norman conversely for design process (Akrich & Latour, 1992; Latour, 1994; Norman, 2013). They all express the similar standpoint that "affordance" needs to be embedded in design so as to guide users to use the product according to what is supposed. Taking a wider view, it can be seen that understanding must take place somewhere, a context where the artefact is used, where the understanding occurs. As Ihde has observed, technology is always only what it is in some cultural and use context, thus giving rise to the "ambiguity of technology." And even in an identified context, the same artefact can be understood differently by different users, highlighting the role of the human agent in understanding. This aspect encompasses skills, aesthetics, creativity etc. which may be very personal. The above is merely a preliminary and incomplete attempt at exploring the factors in the understanding of technology. Yet it is evident that the affordances of a technical artefact, context and human agency play key roles for technological understanding.

Once we are talking about understanding, meaning, and sense-making, we have turned to the field of hermeneutics. The initial, primitive, context-sensitive, always re-interpreted, historically-situated meaning is the core issue in hermeneutics. To some extent it may share its main concern with epistemology, however, it does not seek to reveal the inner structure of cognition as conventional epistemology does, but to shed a light on the condition prior to the theoretical thematization and transformation from our fuzzy lifeworld to mathematized abstract world. Before we start to grasp their structures and build up an abstract theoretical model of them, we have already formed primitive, pre-theoretical knowledge. Hermeneutics can complement what epistemology cannot provide and thus bridges two worlds (Ginev, 1995). Ihde (1990) introduces the notion of "cultural hermeneutics" to demonstrate the cultural embeddedness of technology and to highlight the importance of examining concrete cultural contexts when evaluating technology. Recognizing a set of common foundations, considering technological understanding and hermeneutics of technology may jointly offer valuable insights.

CONCLUSIONS AND PERSPECTIVES

To sum up, I call for more attention to technological understanding and this paper set out to explore how the discussions on scientific understanding can be projected onto technology. By an inquiry from historical and ontological perspectives, it can be reasonably claimed that technology is a more primordial way of knowing than science. However, there is a lack of relevant discussions due to prolonged neglect of technology and materiality in philosophy. Thus, similar discussions of scientific explanation and understanding in philosophy of science can serve as a guidance. A brief examination reveals that adequate scientific explanation does not guarantee the acquisition of all knowledge. Only a confluence of a scientific explanation, human agency and social context can give rise to scientific understanding. The investigation of "scientific understanding" deserves careful consideration. But back to technology, the research topic of technological explanation is already situated among the core concerns in philosophy of technology after the empirical turn. Kroes (1998) defines it as "an explanation of the function of a technological object in terms of the physical structure of that object" (p. 125). A consensus shared among philosophers who have explored this question is that deductive reasoning is insufficient for producing a comprehensive explanation of function in terms of physical structure because of the multistabilities of the physical structure as well as function of a technical artefact.

To obtain a holistic view of how we understand technology, I introduce the notion "technological understanding." It refers to the way in which we make sense of how to interact with a technical artefact. A philosophical reflection on technological understanding is thus a comprehensive investigation into how we come to know a technical artefact with respect to the conditions for sense-making, benefitting technology assessment and providing insight for designers. Furthermore, the acknowledgement of and concern with sense-making of situated, context-sensitive meanings lie within the scope of hermeneutic traditions. Accordingly, hermeneutics can be employed as a productive lens for exploring technological understanding.

The task ahead is to undertake a deeper exploration of the factors within technological understanding in conjunction with hermeneutics. For example, what still remains untouched here is the dimension of art. Given that both technical artefacts and artworks are human creations, can our discussion on technological understanding gain any insight from the hermeneutics of artworks as well?

REFERENCES

Akrich, M., & Latour, B. (1992). A Summary of a Convenient Vocabulary for the Semiotics of Human and Nonhuman Assemblies. In W. E. Bijker & J. Law (Eds.), *Shaping Technology / Building Society: Studies in Sociotechnical Change* (pp. 259–264). MIT Press.

Aristotle. (2000). *Nicomachean Ethics* (R. Crisp, Trans. & Ed.). Cambridge University Press.

Arthur, W. B. (2009). *The Nature of Technology: What it is and how it Evolves*. Simon and Schuster.
Bacon, F. (2000). *Francis Bacon: the New Organon*. Cambridge University Press. (Original work published 1620)
Baker, L. R. (2004). The Ontology of Artifacts. *Philosophical explorations*, *7*(2), 99-111. https://doi.org/10.1080/13869790410001694462
Baker, L. R. (2007). *The Metaphysics of Everyday Life: An Essay in Practical Realism*. Cambridge University Press.
Brey, P. (2010). Philosophy of Technology after the Empirical Turn. *Techne: Research in Philosophy & Technology*, *14*(1). https://doi.org/10.5840/techne20101416
Bunge, M. (1966). Technology as Applied Science. *Technology and Culture*, *7*(3), 329-347.
de Regt, H. W., & Dieks, D. (2005). A Contextual Approach to Scientific Understanding. *Synthese*, *144*, 137-170. https://doi.org/10.1007/s11229-005-5000-4
de Regt, H. W. (2009). Understanding and Scientific Explanation. In *Scientific Understanding: Philosophical Perspectives* (pp. 21-42). The University of Pittsburgh Press.
de Regt, H. W. (2022). Can Scientific Understanding be Reduced to Knowledge?. In *Scientific Understanding and Representation* (pp. 17-32). Routledge. https://doi.org/10.4324/9781003202905-3
de Ridder, J. (2007). *Reconstructing Design, Explaining Artifacts: Philosophical Reflections on the Design and Explanation of Technical Artifacts* [Doctoral Thesis]. TU Delft. https://repository.tudelft.nl/record/uuid:d67f6fe7-59c5-4357-903e-e3c3891e2721
de Solla Price, D. J. (1965). Is Technology Historically Independent of Science? A Study in Statistical Historiography. *Technology and Culture*, *6*(4), 553-568.
Franssen, M., Vermaas, P. E., Kroes, P., & Meijers, A. W. M. (Eds.). (2016). *Philosophy of Technology after the Empirical Turn* (Vol. 23). Springer. https://doi.org/10.1007/978-3-319-33717-3
Friedman, M. (1974). Explanation and Scientific Understanding. *The Journal of Philosophy*, *71*(1), 5-19.
Gardner, P. L. (1994). The Relationship between Technology and Science: Some Historical and Philosophical Reflections. Part I. *International Journal of Technology and Design Education*, *4*, 123-153.
Gibson, J. J. (1979). *The Ecological Approach to Visual Perception*. Houghton Mifflin.
Ginev, D. (1995). Between epistemology and hermeneutics. *Science & Education*, *4*, 147-159.
Heelan, P. A. (1998). The scope of hermeneutics in natural science. *Studies in History and Philosophy of Science Part A*, *29*(2), 273-298.
Heelan, P., & Schulkin, J. (1998). Hermeneutical philosophy and pragmatism: A philosophy of science. *Synthese (Dordrecht)*, *115*(3), 269-302.
Heidegger, M. (1962). *Being and Time* (J. Macquarrie & E. Robinson, Trans.). Harper & Row. (Original work published 1927)

Heidegger, M. (1977). *The Question Concerning Technology and Other Essays* (W. Lovitt, Trans.). Harper and Row.
Hilpinen, R. (1992). On Artifacts and Works of Art 1. *Theoria*, *58*(1), 58-82. https://doi.org/10.1111/j.1755-2567.1992.tb01155.x
Houkes, W., Kroes, P., Meijers, A., & Vermaas, P. E. (2011). Dual-Nature and Collectivist Frameworks for Technical Artefacts: A Constructive Comparison. *Studies in History and Philosophy of Science Part A*, *42*(1), 198-205. https://doi.org/10.1016/j.shpsa.2010.11.002
Houkes, W., Vermaas, P. E., Dorst, K., & De Vries, M. J. (2002). Design and Use as Plans: An Action-Theoretical Account. *Design studies*, *23*(3), 303-320. https://doi.org/10.1016/S0142-694X(01)00040-0
Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press.
Ihde, D. (2009). *Postphenomenology and Technoscience: The Peking University Lectures*. Suny Press.
Ihde, D. (2010). *Heidegger’s Technologies: Postphenomenological Perspectives*. Fordham University Press.
Khalifa, K. (2012). Inaugurating Understanding or Repackaging Explanation?. *Philosophy of Science*, *79*(1), 15-37. https://doi.org/10.1086/663235
Kroes, P. (1998). Technological Explanations: The Relation between Structure and function of technological objects. *Society for Philosophy and Technology Quarterly Electronic Journal*, *3*(3), 124-134. https://doi.org/10.5840/techne19983325
Kroes, P. (2006). Coherence of Structural and Functional Descriptions of Technical Artefacts. *Studies in History and Philosophy of Science Part A*, *37*(1), 137-151. https://doi.org/10.1016/j.shpsa.2005.12.015
Kroes, P. (2010). Engineering and the Dual nature of technical artefacts. *Cambridge journal of economics*, *34*(1), 51-62. https://doi.org/10.1016/j.shpsa.2005.12.015
Kroes, P., & Meijers, A. (2006). The Dual Nature of Technical Artefacts. *Studies in History and Philosophy of Science*, *37*(1), 1-4. https://doi.org/10.1016/j.shpsa.2005.12.001
Kuhn, T. S. (1971). The Relations between History and History of Science. *Daedalus*, 271-304.
Kuhn, T. S. (1997). *The Structure of Scientific Revolutions* (Vol. 962). University of Chicago press.
Latour, B. (1994). On Technical Mediation. *Common Knowledge*, *3*(2), 29-64.
Latour, B. (1999). *Pandora’s Hope: Essays on the Reality of Science Studies*. Harvard university press.
Layton Jr, E. T. (1974). Technology as Knowledge. *Technology and culture*, *15*(1), 31-41. https://doi.org/10.2307/3102759
Lenhard, J. (2009). The Great Deluge: Simulation Modeling and Scientific Understanding. In H. W. de Regt, S. Leonelli, & K. Eigner (Eds.), *Scientific Understanding. Philosophical Perspectives* (pp. 169-186). University of Pittsburgh Press.

Lindberg, D. C. (2010). *The Beginnings of Western Science: The European Scientific Tradition in Philosophical, Religious, and Institutional Context, Prehistory to AD 1450*. University of Chicago Press.
Lipton, P. (2009). Understanding without Explanation. In H. W. de Regt, S. Leonelli, & K. Eigner (Eds.), *Scientific Understanding: Philosophical Perspectives* (pp. 43–63). University of Pittsburgh Press.
Meijers, A. W. (2000). The Relational Ontology of Technical Artifacts. *Research in philosophy and technology*, *20*, 81-98.
Mitcham, C. (1994). *Thinking Through Technology: The Path Between Engineering and Philosophy*. University of Chicago Press.
Niiniluoto, I. (2016). Science vs. Technology: Difference or Identity? *Philosophy of Technology after the Empirical Turn*, 93-106. https://doi.org/10.1007/978-3-319-33717-3_6
Norman, D. (2013). *The Design of Everyday Things: Revised and Expanded Edition*. New York.
Preston, B. (2022). Artifact. In E. N. Zalta & U. Nodelman (Eds.), *The Stanford Encyclopedia of Philosophy*. Stanford University. https://plato.stanford.edu/archives/win2022/entries/artifact/
Pitt, J. C. (2000). *Thinking about Technology: Foundations of the Philosophy of Technology*. Seven Bridges Press.
Pitt, J. C. (2009). Technological Explanation. In *Philosophy of technology and engineering sciences* (pp. 861-879). North-Holland.
Salmon, W. C. (1990). *Four Decades of Scientific Explanation*. University of Pittsburgh Press. https://doi.org/10.2307/j.ctt5vkdm7
Schurz, G., & Lambert, K. (1994). Outline of a Theory of Scientific Understanding. *Synthese*, *101*, 65-120. https://doi.org/10.1007/BF01063969
Schäfer, D. (2019). *The Crafting of the 10,000 Things: Knowledge and Technology in Seventeenth-Century China*. University of Chicago Press.
Song, Y. (2011). *Tian gong kai wu* [天工开物] (J. Pan, Y. Wang, H. Wang, & Y. Liu, Trans.). Guangdong Education Publishing House.
Sorell, T. (2013). *Scientism: Philosophy and the Infatuation with Science*. Routledge.
Trout, J. D. (2002). Scientific Explanation and the Sense of Understanding. *Philosophy of Science*, *69*(2), 212-233. https://doi.org/10.1086/341050
Vermaas, P. E., & Houkes, W. (2006). Technical Functions: A Drawbridge between the Intentional and Structural Natures of Technical Artefacts. *Studies in History and Philosophy of Science Part A*, *37*(1), 5-18. https://doi.org/10.1016/j.shpsa.2005.12.002
Vincenti, W. G. (1990). *What Engineers Know and how They Know it*. Johns Hopkins University Press.

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Research article

On the Symbolic Dimension of Technology: A Phenomenological Approach

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Abstract

Phenomenological-hermeneutic approaches to the philosophy of technology explore the world-disclosing role of technical artifacts. These approaches often lack a deeper engagement with their symbolic dimension. This paper addresses that gap by asking how the symbolic dimension of technical artifacts can shape the ways in which we relate to and disclose the world. To this end, the paper distinguishes four distinct modes in which the symbolic dimension of technical artifacts can manifest itself in experience. As demonstrated through a range of examples, the symbolic dimension may present itself in ways that either a) conceal it, b) remain in the background, c) impose themselves upon us, or d) challenge us to engage in active interpretation. As the paper argues, each mode gives rise to a different stance toward the artifact, thereby shaping the way we understand both the artifact and the world more broadly. The approach is phenomenologically motivated, which means that the vocabulary developed here must always be understood from the perspective of a subject experiencing the artifact. To clarify what is distinctive about this perspective, the paper also contrasts it with alternative approaches, such as cultural hermeneutics, which likewise addresses the symbolic dimension of technology but does so by adopting a general interpretive-theoretical stance rather than beginning from the situated experience of the subject, as the phenomenological perspective does.

Keywords: Technology Hermeneutics; Phenomenology; Symbolic Dimension of Technology; Everyday Experience; World Discloser

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Научная статья

О символическом измерении технологий: Феноменологический подход

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Аннотация
В феноменологически-герменевтических подходах к философии техники, которые исследуют роль технических артефактов в раскрытии мира, часто не хватает более глубокого взаимодействия с их символическим измерением. В этой статье рассматривается этот пробел, задаваясь вопросом, как символическое измерение технических артефактов может формировать способы, которыми мы соотносимся с миром и раскрываем его. С этой целью в статье выделяются четыре различных способа, с помощью которых символическое измерение технических артефактов может проявляться в опыте. Как показано на ряде примеров, символическое измерение может представлять себя способами, которые либо а) скрывают его, б) остаются на заднем плане, в) навязываются нам или г) бросают нам вызов, побуждая к активной интерпретации. Как утверждается в статье, каждый способ порождает различную позицию по отношению к артефакту, тем самым формируя наше понимание как артефакта, так и мира в целом. Подход имеет феноменологическую подоплеку, что означает, что разработанная здесь лексика всегда должна пониматься с точки зрения субъекта, переживающего опыт. Чтобы прояснить отличительные черты этой перспективы, в статье она также противопоставляется альтернативным подходам, таким как культурная герменевтика, которые также рассматривают символическое измерение технологии, но делает это, придерживаясь общей интерпретативно-теоретической позиции, а не отталкиваясь от конкретного опыта субъекта, как это делает феноменологическая перспектива.

Ключевые слова: Герменевтика технологии; Феноменология; Символическое измерение технологии; Повседневный опыт; Раскрытие мира

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INTRODUCTION

In phenomenologically-hermeneutically oriented technology research, as pioneered by such as Martin Heidegger and Don Ihde, the core focus is on questions regarding the world's disclosure and meaning-making through technology (Ihde, 2010).[1] How does technology transform our relation to ourselves and to the world? How does the technologically textured lifeworld shape the manner in which we integrate ourselves into it on a daily basis? And how can technological experience be more precisely understood in its embodied dimension? Questions such as these have been addressed in recent decades within a variety of frameworks – postphenomenology, material hermeneutics, hermeneutics of technology, and others. The present work is intended as a contribution to this multifaceted debate, as it deals with an aspect that has often been marginally addressed in this debate, namely the symbolic dimension of technology. There is hardly any in-depth engagement with this, which might be due to the fact that when we think of technology, we tend to think of its use, not its symbolic dimension.[2] However, a phenomenologically oriented hermeneutics of technology should also address the symbolic dimension of technology because the way we disclose the world is not only dependent on the use of technological artifacts but also on their symbolic dimension.

This article explores the question of how the symbolic dimension of technical artifacts can influence the way in which we disclose the world. To this end, I develop a differentiated vocabulary that enables a more precise articulation of the symbolic dimension of technology. Since the term "symbolic" is itself highly complex and risks being employed in a vague or diffuse manner, I begin by specifying what I mean by the symbolic dimension of technology. I then proceed – drawing on a variety of examples, ranging from AI-generated music to luxury sports cars and complex architectural structures – to examine the different ways in which the symbolic dimension of technology or technical constructs can shape our modes of world-disclosure. My research is phenomenologically motivated: all conceptual determinations I make here must therefore be understood from the perspective of a subject in lived experience, to whom the symbolic content of an artifact is disclosed.

[1] For a good reconstruction of this debate see Jure Zovko's 2023 paper „Expanding hermeneutics to the world of technology."

[2] **An exemplary case in point is Arun Kumar Tripathi's paper „*Hermeneutics of Technological Culture*" (2017) which offers a valuable overview of the postphenomenological debate on technology but omits any discussion of the symbolic dimension of technology – despite its explicit focus on the cultural dimension of technological experience.** One exception, however, is a conference volume edited by Epp et al. in the field of the sociology of technology, which explicitly refers to the "symbolic dimension of technologies" (Epp et al., 2002, p. 3, my translation). Nevertheless, here too the symbolic dimension is strongly interpreted in terms of the use of technology. Moreover, as the editors admit, there is a lack of conceptual systematics in the exploration of the symbolic dimension of technology (Epp et al., 2002, p. 8). Thus, it remains methodologically unclear in this volume what it actually means to deal with the symbolic dimension of technology.

WHAT IS MEANT BY THE SYMBOLIC DIMENSION OF TECHNOLOGY?

To begin, it is necessary to clarify what exactly is meant by the expression *symbolic dimension of technology*. Two interpretations seem possible. First, the term may refer to the fact that technical artifacts make use of symbols or icons in order to communicate information about particular states of affairs. Second, it may refer to the idea that technical artifacts can possess a surplus of meaning – an additional semantic layer that exceeds their functional or instrumental use. The former interpretation has been analyzed by Ihde under the concept of *hermeneutic relations*, which refers to the use of technological artifacts that mediate aspects of reality not directly perceptible to us (Ihde, 1990, p. 80-97). For example, when I use a measuring device to assess different frequencies in an electric circuit, I see on the display a symbolic representation of those frequencies, from which I must indirectly infer the phenomenon. This symbolic representation must be interpretable – hence Ihde’s designation of such world-relations as hermeneutic. This symbolic representation serves a functional purpose and is therefore tied to a specific practical utility.

What follows, however, is concerned with the second meaning of the symbolic. My interest lies in a symbolic dimension constituted by a surplus of meaning – one that cannot be reduced to mere functionality. This surplus, which any technical artifact can in principle acquire, endows the artifact with expressive character and influences how I relate to it, insofar as I am affected by its symbolic content. Even here, one can speak of a hermeneutic relation, insofar as the symbolic dimension must be disclosed interpretively. For instance, I may enter an electric SUV and initially view it simply as a means of transportation from point A to point B. In that case, its symbolic dimension does not affect the way I experience the ride. The situation changes, however, once I interpret the SUV as an environmentally damaging artifact that, despite being electrically powered, falsely suggests ecological sustainability while it is in fact highly resource-intensive. And so, if I am environmentally conscious, Ienter the vehicle not without a sense of unease and perhaps even indignation at the current state of the automotive industry. What becomes salient here is not the specific environmental footprint of this particular vehicle, but a broader socio-political imbalance that the SUV seems to embody. The mode of world-relation that is constituted during the ride is thus fundamentally different from perceiving the SUV merely as a neutral means of transportation. In one case, the symbolic dimension plays no role; in the other, it becomes significant, as it may be interpreted as an emblem of the failure of the ecological transition – depending on what might one call hermeneutic standpoint.

Whether or not I disclose the symbolic dimension of an artifact depends on my hermeneutic standpoint, which determines whether I am able to perceive this dimension at all. But is this a purely subjective matter? By no means. The constitution of the object also plays a role. In the case of the electric SUV, it is quite natural – under current conditions – to associate it with political compromises in dealing with the ecological crisis. With an e-bike, which also serves as a means of transportation, such associations are less likely or may take on an entirely different direction.

Let us therefore summarize: the hermeneutic standpoint of the interpreting subject plays a decisive role in disclosing the symbolic dimension of technical artifacts, but so too does the constitution of the artifact itself. Accordingly, when reflecting on the symbolic dimension of technology, we find ourselves in a discursive situation similar to that of affordance theory – except that the focus here is not on the material cues of a technical artifact that suggest particular courses of action (Gibson 2015), but rather on interpretive possibilities, or more precisely, on a fundamental, context-sensitive mode of understanding in human–technology interaction. The way in which the symbolic dimension can affect our relation to the world goes beyond mere instrumental use.

CULTURAL-HERMENEUTIC VS. PHENOMENOLOGICAL APPROACH

It is now necessary to further refine the concept of the symbolic dimension of technical artifacts for the purposes of this analysis. Simply stating that the term addresses a surplus of meaning irreducible to instrumental function remains too vague. One can approach the symbolic dimension of technology in at least two distinct ways, which I aim to delineate more clearly in what follows. Depending on the chosen approach, one will inevitably engage with different domains of objects. One approach, drawing on Ihde, I shall refer to as the cultural-hermeneutic approach (Ihde, 1990, pp. 124-161). This approach is concerned with uncovering the cultural – or more precisely, symbolic – layers of meaning that attach to a technical artifact from a theoretically interpretive standpoint. The second approach I intend to pursue here is phenomenological in nature, in that it reflects on our technologically mediated relations to the world as they emerge from our situatedness and our everyday dealings with technical artifacts.

Within the *cultural-hermeneutic approach*, a historian or cultural anthropologist might, for example, study the invention of the clock and interpret it as a symbol of modernity. Or one might turn to the invention of the lightning rod and examine the symbolic significance it held during the French Revolution. In general, adopting a cultural-hermeneutic perspective entails attributing symbolic meaning to all technical artifacts, insofar as they are simultaneously cultural artifacts and can potentially be understood as expressions of the Zeitgeist. This interpretive process may, depending on the creativity of the interpreter, become quite speculative. One might recall Slavoj Žižek's popular and humorous interpretation of various toilet types across Europe as expressions of distinct ideological orientations (Open Culture, 2016). For instance, the French toilet – which swiftly flushes away excrement before it becomes visible – is taken by Žižek as indicative of a revolutionary mindset: a readiness to embrace the new without regard for the old, or for what might be lost in the process.

In contrast, a *phenomenological approach* to the symbolic dimension of technology focuses on how technological artifacts shape our everyday experiences. The point here is not merely to establish, in principle, that technical artifacts can be examined with regard to their symbolic dimension. Rather, the focus lies on the fact that there are specific situations in which the symbolic dimension of technical artifacts shapes our everyday experience of technology in a distinctive way – and it is precisely this phenomenon that requires closer examination. From a phenomenological perspective, the aim is to articulate aspects of everyday experience that usually remain implicit – experiences that are taken for granted yet lack adequate conceptual articulation. Don Ihde, in particular, has impressively advanced such phenomenological elucidation by introducing concepts such as embodiment relation, hermeneutic relation, alterity relation, and background relation, all of which serve to articulate the ways in which our relation to the world is mediated by technology. I have already addressed his notion of the *hermeneutic relation* and pointed out that this concept relies on a predominantly functional understanding of symbols. When it comes to the question of how the symbolic dimension of technology may influence our technologically mediated relations to the world, Ihde's vocabulary proves to be quite limited – and it is precisely at this juncture that my own reflections begin.

DIFFERENT MODES OF BEING AFFECTED BY THE SYMBOLIC DIMENSION OF TECHNOLOGY

With the examples of the electric SUV and e-bike it has only been suggested so far that the symbolic dimension of technical constructs can affect us in such a way that our mode of world-disclosure may shift or even change entirely. From a phenomenological perspective, however, this can be articulated in more detail. As I will now show, there are various ways in which the symbolic dimension of technical artifacts can affect us. I propose that we distinguish, on a fundamental level, four different ways in which the symbolic dimension of technology can impact our relation to the world, depending on how it *appears to us*. The symbolic dimension of technology can be encountered in the form of (a) concealment, requiring special effort or specific knowledge in order to be perceived at all; (b) backgrounded presence; (c) imposition; or (d) a form that challenges us to engage interpretively with it. In each of these modes of appearance, the symbolic dimension operates in a distinctive manner, which I aim to elaborate in this section.

It is important to note that I am not concerned here with explaining how one's attention comes to be directed toward the symbolic dimension of a technical artifact, or under what conditions this is more or less likely to occur. Such questions would lead us into psychological analysis, which is not my objective. Rather, I seek a phenomenological analysis that begins at the moment the symbolic dimension of an artifact is disclosed. The following descriptions proceed from the assumption that the symbolic dimension of a technical artifact is given, and they address the question of how it presents itself when it is given.

The Symbolic Dimension Conceals Itself

To begin with, let me reiterate that the disclosure of the symbolic dimension of technology always involves a hermeneutic relation, insofar as this dimension must be interpretively accessed. There is no objective standpoint from which to perceive it, since the interpretive horizon from which I disclose the world is always subjective. The knowledge I possess about a thing plays a crucial role in how I interpret it. For example, if I listen on my laptop to the so-called 10th Symphony of Beethoven – “Beethoven X” –

my listening experience will be fundamentally different from listening to the 9th Symphony, simply because I know that the third and fourth movements of the 10th were generated by artificial intelligence. In addition to the fact that artistic performances often generate or are shaped by a symbolic dimension, the so-called 10th Symphony contains an additional symbolic layer, insofar as it spectacularly showcases the progress of a technological development.[3] This symbolic dimension of the technical construct frames my interpretive access and shifts the way in which I make sense of the musical piece.

My experience of listening to the so-called 10th Beethoven Symphony would, however, be quite different if I were approaching the piece from an entirely different knowledge base and, accordingly, from a different hermeneutic standpoint. If, for instance, I generally have difficulty distinguishing between Beethoven's various symphonies and am not well-versed in this repertoire, I am likely to accept the 10th Symphony as an authentic composition if it is presented to me as such. Only someone familiar with Beethoven's oeuvre might, upon listening, suspect that this is not an original symphony but rather a composition that imitates Beethoven's stylistic signature[4] – knowing, of course, that Beethoven never completed a tenth symphony. Yet regardless of how much I know about Beethoven's work or how refined my listening abilities may be, in all cases it is fair to say that the AI-generated piece is explicitly designed to imitate the sound of a Beethoven symphony so convincingly that it might easily be taken for the real thing. The symbolic dimension of this AI-generated work does not impose itself immediately; rather, it conceals itself – or more precisely, it *reveals itself in such a way that it remains hidden*. In this sense, the symbolic dimension of the AI-generated symphony can only affect our listening experience through an act of disclosure, in which we come to realize it is, in fact, generated by AI. When this symbolic dimension presents itself to me, it does so precisely in the mode of concealment.

This mode of perception can also be illustrated by the example of cosmetic surgery. Consider a particularly successful case of facial lifting in which the intervention is not readily noticeable. If I have long been impressed by how youthful a friend's face appears and then, upon closer inspection or by being informed, I learn that the face has undergone aesthetic procedures for years, I may be surprised not to have noticed earlier. If this realization does not concern me further, I may simply move on without giving it another thought. But let us suppose instead that my initial surprise leads me to examine my friend's face more closely, becoming preoccupied with the subtle aesthetic alterations I had not previously suspected. In that moment, a symbolic dimension may begin to emerge – one that momentarily lends the face an additional layer of meaning, as I now see in it the expression of a desire to halt or even transcend the aging process. My friend's face deceives me insofar as it conceals its true age. What is at stake here, then, is a symbolic dimension that shapes the way I see the face – yet it does not disclose itself immediately, as in the cases where it imposes itself (see below), but rather in a manner that is concealed.

[3] While lead programmer Ahmed El-Gamal concedes that an arranger was needed to compile the AI-generated material (BR-KLASSIK, 2021), the result remains impressive and indicative of the technology's possibilities.
[4] Dirk Kaftan, who conducted the premiere of Beethoven X, emphatically asserts that the composition cannot genuinely be considered *Beethoven* (BR-KLASSIK, 2021).

The Symbolic Dimension Remains in the Background

There is a difference between the symbolic dimension of a technical artifact presenting itself in such a way that it conceals itself, and presenting itself in such a way that it remains in the background. At first glance, the expressions "concealing itself" and "remaining in the background" may appear similar, since in both cases something does not present itself directly. However, they involve important differences, which are crucial to my argument here. That which conceals itself is not meant to be seen, whereas that which remains in the background becomes visible as soon as one attends to it. These two formulations are intended to mark distinct categories of experience, describing different ways in which the symbolic meaning of a technical artifact can manifest itself to us. For this reason, I want to draw a strict terminological distinction between them. The first pertains to forms of experience typically associated with technologies that operate through imitation or deception, as illustrated in the earlier examples of the AI-generated Beethoven symphony or subtle cosmetic surgery. The second refers to technical artifacts whose symbolic charge has diminished over time, such that we no longer immediately associate the object with any symbolic meaning. In such cases, it is largely up to us to recognize and articulate this dimension.

Let us take a mundane situation as an example: a person watches an airplane flying overhead. This may be a fleeting form of perception, such that the observer registers nothing more than the airplane itself, along with the clouds it passes through and the blue sky serving as the visual background. The airplane, after all, is a familiar object – one whose symbolic dimension no longer imposes itself as it might have done in the early twentieth century. Of course, I may nonetheless, upon seeing the airplane, also reflect on its symbolic dimension. I may even find myself momentarily struck by the thought that this technological marvel represents the realization of a longstanding human dream. In such a moment, I no longer perceive the airplane merely as a flying object, but as the symbolic realization of a technical utopia.

Naturally, one need not be filled with awe at the sight of a plane in flight, as air travel today is hardly remarkable. For most inhabitants of the Western world, boarding a plane at least once a year is almost a matter of routine. The experience I wish to describe here takes the form of the symbolic dimension of an artifact disclosing itself to me precisely because *I am the one attending to it.* It arises as something that stands out to me – something that exceeds the immediately visible. The symbolic dimension of the airplane is there, but it does not force itself upon me; rather, I become aware of it in such a way that it emerges from the background of my understanding and is brought into the foreground of my attention. This, then, is not a matter of revealing something hidden, asin the case of concealment, but of noticing a dimension of meaning that is already present, yet requires my attentiveness in order to be perceived.

Let us take, as an alternative example, the European Central Bank tower (ECB Tower) in Frankfurt, located adjacent to a park. A passerby may initially perceive it simply as a tall, transparent building made of glass. It is, of course, easy to adopt a cultural-hermeneutic perspective here and interpret the building's transparency as a symbol for the idea of transparency itself – perhaps as an expression of conscientious work practices that are open to public scrutiny. Of interest here, however, is the phenomenological perspective, which focuses on the lived experience of this symbolic dimension. Consider the case of a passerby who pauses to look at the ECB Tower. For such a person, the symbolic dimension of the building may not impose itself, especially given that there are now many buildings with a similarly transparent appearance – so many, in fact, that one may not be inclined to reflect on the symbolic character of this particular building at all. That is to say: the passerby could, if sufficiently attentive, perceive the symbolism evoked by the ECB Tower's transparency; but they could just as easily overlook it, simply because it does not strike them. In this case, the symbolic dimension of the ECB Tower remains in the background for the observer – it does not conceal itself, however, in the sense that it can become accessible simply by attending to it. And if the observer does attend to this symbolic dimension, then the resulting experience takes the form of an act of attentiveness: the observer becomes the one who grants attention to the object, allowing its symbolic dimension to step out of the background and into the foreground of awareness.

A necessary condition for this kind of experience is that the subject, given their hermeneutic presuppositions, is capable of discerning the symbolic dimension inherent in the artifact. In this sense, the subject must possess the background knowledge that allows transparent architectural forms to be understood as symbolic expressions of transparency itself. If this interpretive framework is lacking, the symbolic dimension of the building cannot disclose itself to the subject and thus cannot appear from out of the background. The notion of "remaining in the background" should not be understood in an objectivist sense, as though there existed a universal symbolic meaning of the transparent building merely waiting to be uncovered. If the passerby is unable to perceive the symbolic dimension evoked by the building's transparency, then this symbolic dimension is not merely in the background – it simply does not exist for them.

To further illustrate this point, consider that the ECB Tower was constructed in conjunction with the former Großmarkthalle, a site imbued with symbolic meaning, as an architectural masterpiece of the 1920s which was in the Third Reich repurposed to serve as a collection point for the deportation of Jewish residents (Draghi, 2015). For a passerby who is unaware of this historically charged architectural constellation, this dimension simply does not exist – and consequently, it cannot be experienced.

The Symbolic Dimension Imposes Itself

There are also technical artifacts whose symbolic dimension tends to impose itself upon us due to their inherent expressiveness. When searching for examples of such experiences, it makes sense to consider objects that were deliberately designed to symbolize something specific – objects whose symbolic dimension we can hardly avoid recognizing in the very act of perceiving or using them.

Let us consider, for instance, the example of a red Porsche or so-called "poser bikes" equipped with modified exhaust systems. In both cases, the symbolic dimension of the object imposes itself quite directly: in the case of the red Porsche, through its elegant design; in the case of the poser bike, through the loud noise produced by its customized exhaust. Those who drive such vehicles do so not merely to get from one place to another, but also to make a deliberate statement. The red Porsche, for example, is designed to be interpreted as a symbol of luxury, whereas the poser bike is intended to draw attention – and perhaps even to provoke. No matter how one chooses to interpret these objects – whether as expressions of freedom or of clichéd masculine fantasies – in both cases, the symbolic dimension asserts itself and shapes the way in which we perceive these objects, or even the way we engage with the world through them. A passerby might feel irritated by the presence of poser bikers, while the person riding such a bike with enthusiasm may experience the world in a markedly different affective mode. The fact that these vehicles elicit certain affective responses is not incidental but rather an intended effect, integral to their design. In both cases a particular symbolic charge is deliberately embedded and meant to be projected outward.

The red Porsche and the modified motorcycle thus serve as two particularly illustrative examples of technical artifacts whose symbolic dimension imposes itself precisely because it is constitutive of their identity – indeed, they are designed in such a way that this symbolic dimension is perceived. Whether this dimension actually imposes itself upon me is, of course, another matter entirely; I may, for instance, be so lost in thought that I fail to notice the loud poser bike passing by, or I might simply remain indifferent to it. As previously noted, these reflections are no concered to assume a psychological perspective that seeks to determine the conditions under which one becomes aware of an artifact’s symbolic meaning. Rather, I am interested in the mode of experience – how the symbolic dimension of an artifact manifests itself to us. My claim is therefore not that we are somehow determined to perceive the symbolic dimension when, say, a red Porsche or a poser bike passes us. Rather, what I wish to describe is that, once this symbolic dimension presents itself, it does so in a manner that imposes itself upon us.

Undoubtedly, we can also consider examples in which the symbolic dimension imposes itself on us without being constitutive for the artefact. Consider, for instance, the case of a Tesla vehicle, whose public image has been inextricably linked to that of Elon Musk. It is well known that Musk made a highly controversial gesture during the inauguration of U.S. President Trump – a gesture that was widely interpreted in public discourse as a Nazi salute. Now let us assume that we are dealing with a Tesla owner deeply troubled by the political developments in the United States, perceiving them as highly problematic. If this individual now enters their Tesla and involuntarily associates the car with these political upheavals, this cannot be dismissed merely as a subjective projection or an active interpretative effort on the part of the driver.[5]

From a phenomenological perspective, a certain symbolic dimension imposes itself here, leading the driver to experience the vehicle in light of these broader political contexts. This interpretative framing – whereby the driver associates the Tesla with unwelcome political transformations – presents itself to the subject almost unavoidably. Much like the case of the poser bike, the Tesla vehicle confronts its users with a symbolic dimension that asserts itself. However, unlike the poser bike, this vehicle was not

[5] As a result, special stickers were developed for frustrated Tesla drivers allowing them to explicitly distance themselves from Elon Musk. Various media outlets have reported on decals with slogans such as “I bought this before I knew Elon was crazy” (Mones, 2023).

designed so as to assert the symbolic meaning that temporarily attached itself to the Tesla and that is therefore not constitutive of the artifact's identity.

Let us now consider another example that illustrates the same idea I demonstrated with the Tesla vehicle. I would like to recount an anecdote here: A friend of mine, who works on German memory culture with regard to the Holocaust, traveled to Israel some time ago and made a striking observation. He noticed that the same red double-decker trains that are ubiquitous in Germany also operate in Israel – something that took him by surprise, as he strongly associated these trains with Germany. At first glance, this observation may seem unremarkable, especially to those who have encountered these trains in other countries. Yet for my friend, who perceived the trains as bearing a distinctly German identity, a symbolic dimension imposed itself unavoidably. He could not help but interpret this shared design as a gesture of historical reparation, reasoning that such a resemblance could hardly be coincidental.

Figure 1. Red double-decker train in Israel *Note. From* Doppelstockzug *[Photograph], by Israel Magazin, 2010,* https://www.israelmagazin.de/wp-content/uploads/2010/05/doppelstockzug-550.jpg.

Figure 2. Red double-decker train in Germany *Note. From* DBpbzf 763.5 Remagen *[Photograph], by Qualle, 2014, Wikimedia Commons,* https://upload.wikimedia.org/wikipedia/commons/thumb/f/fd/DBpbzf_763.5_Remagen.jpg/495px-DBpbzf_763.5_Remagen.jpg.

What exactly this symbolic dimension consists in – whether it expresses a sense of solidarity between the two countries or symbolizes a gesture of historical reparation – can remain an open question. Nor is it particularly relevant here that these trains were manufactured by a Canadian company, Bombardier, whose production sites happen to be located in Germany, which somewhat complicates the idea of a straightforward German-Israeli connection. My aim is not to determine which interpretation is correct or whether it is well-founded. What matters is that this symbolic dimension imposed itself upon my friend and directly shaped the way he perceived and experienced the Israeli railway.

When the symbolic dimension imposes itself upon me, I experience myself as a *witness to an occurrence* – an occurrence to which I am inevitably drawn to respond interpretively. Unlike the case where the symbolic meaning needs to be recovered from a background (see above), I do not experience myself as the agent who actively brings the symbolic content to light through deliberate attention to the object. Rather, in the scenarios described here, I have no real choice but to become aware of the symbolic dimension, for it simply befalls me.

The Symbolic Dimension Challenges Us

Finally, the symbolic structure of technical artifacts can also present itself in such a way that it challenges us to interpret its meaning precisely because we are not entirely sure how to understand it in the first place. In such cases, the artifact confronts us almost like a subject, prompting us to adopt a reflective, interpretive stance in which we are called upon to draw on our own creativity to make sense of what we see. This, as I aim to show, constitutes yet another kind of experience – distinct from the kind in which the symbolic dimension of an artifact imposes itself upon us. The type of experience I describe here typically arises when we encounter technical artifacts that, to borrow a phrase by Theodor W. Adorno, possess a “character of enigma” (“Rätselcharakter”) (Adorno, 1973, p. 185). These are artifacts that invite us to take note of their symbolic dimension in a way that calls for an interpretive, contemplative attitude.

Let us take, as a particularly striking example, an artifact from the world of art: the installation *Black Flags* by the American choreographer William Forsythe. In this piece, we witness enormous – indeed, almost monstrous – robotic arms moving large black flags through space in a captivating choreography.

Figure 3. Black Flags*, William Forsythe, 2014*
Photo: Julian Gabriel Richter

Undoubtedly, we are dealing here with a technical artifact. Yet this artifact performs an action we are unable to readily categorize. We do not know what the purpose of this movement is; rather, we are invited – indeed compelled – to reflect on this simultaneously monstrous and elegant configuration. We are prompted to ask what kind of symbolic expression is being enacted here. In contrast to the tuned "poser bike," whose loud exhaust we can easily interpret within familiar symbolic frameworks, *Black Flags* eludes such conventional categorization. The symbolic dimension evoked by this artwork resists straightforward conceptual fixation.[6]

With the *Black Flags* installation, I have chosen an example from the world of art. However, it is certainly not only artworks that can elicit the kind of experience I wish to highlight – namely, an encounter with a technical artifact in which its symbolic dimension challenges us to interpret it. Alternatively, we might consider unusual architectural structures, such as the Selfridges Building or the Walkie Talkie skyscraper (sometimes dubbed "Walkie Scorchie") – constructions whose unconventional forms likewise provoke us to engage not only with their physical design but also with the symbolic meanings they might embody. When we become aware of the symbolic dimension of such buildings, we typically adopt a contemplative and engaged interpretive stance – one in which interpretive frameworks do not present themselves readily, but rather compel us to formulate our own questions.

CONCLUSIONS

To summarize, there are indeed a variety of ways in which the symbolic dimension of an artifact can present itself to us. Depending on how this dimension manifests itself, we adopt different interpretive attitudes from which we come to discern symbolic meaning.

In some cases, the symbolic meaning imposes itself upon us, making us witnesses to an event in which this meaning seems to emerge spontaneously. Here, the symbolic content reveals itself without requiring any active interpretive effort on our part – the interpretive frame, so to speak, precedes our reflection. For instance, the symbolic dimension of a poser bike might present itself to me unavoidably: I hear its loud engine, feel provoked by the noise, and consequently label the rider a poser.

By contrast, a different kind of experience arises when we must exert interpretive effort ourselves in order to uncover the symbolic content of an artifact. In such cases, the symbolic dimension presents itself in a way that remains in the background, so to speak, and must be actively brought into the foreground. Here, we do not assume the role of a passive witness, but rather that of an attentive observer who discloses the symbolic meaning of the artifact through their own capacity for discernment. I have illustrated this with the example of a transparent building such as the ECB Tower. While the building's transparent appearance indeed evokes a symbolic dimension – suggesting notions of

[6] On the artist's website, one finds a brief interpretative note: "Two industrial robots are programmed to choreographically propel two large black flags with a digital precision conceptually approaching Platonic ideals" (Forsythe, n.d.). Yet rather than providing interpretive clarity, this description opens up even more questions – particularly for the engaged interpreter.

openness or accountability – this meaning does not impose itself upon me. Given the prevalence of transparent architecture today, I am not necessarily drawn into the symbolic register. It is only through conscious reflection that I may come to notice and articulate this layer of meaning.

In some cases, the symbolic dimension of a technological artifact may present itself in a manner that conceals itself from us. Typically, this involves technologies that operate through imitation or simulation, such that we remain unaware of their artificial nature. It is only when we discover that we are dealing with a technology designed to deceive or mimic that its symbolic dimension becomes accessible. I have illustrated this with the example of the AI-generated Tenth Symphony of Beethoven: we interpret the musical piece in a fundamentally different way once we realize that it was composed not by Beethoven, but by an artificial intelligence designed to emulate his style. In such instances, we find ourselves in the role of a discoverer – someone who has unveiled something hidden. The symbolic dimension emerges through the very act of this uncovering.

A particular and exceptional role emerges when we find ourselves challenged by an artifact in such a way that we feel compelled to interpret its symbolic meaning – not because it readily presents itself, but because its very ambiguity provokes us. In such cases, the artifact confronts us almost like a subject, inviting us to engage in a thoughtful and creative act of interpretation. We experience ourselves as questioning and meaning-making beings, immersed in an aesthetic mode of reflection.

Certainly, I could express myself in much simpler terms and merely state that technical artifacts can also possess symbolic meaning. However, if we limit ourselves to this general assertion – that technical artifacts may carry symbolic significance beyond their practical utility – it remains quite unclear how exactly this symbolic dimension manifests itself in our experience. Phenomenological analysis, by contrast, is concerned precisely with the nuances of how we experience things. It operates under the maxim that what is nearest to us is often also the most distant, and thus requires a particular effort to be brought into view. This, as I have sought to demonstrate here, also applies to the way in which the symbolic dimension of technical artifacts becomes manifest to us. More precise research in this area, however, remains in its early stages.

REFERENCES

Adorno, T. W. (1973). *Ästhetische Theorie [Aesthetic Theory]*. Suhrkamp.

BR-KLASSIK. (2021, October 9). *Künstliche Intelligenz vollendet Beethovens 10. Symphonie: Die Kritik zur Uraufführung in Bonn [Artificial Intelligence Completes Beethoven's 10th Symphony: The Review of the Premiere in Bonn]*. https://www.br-klassik.de/aktuell/news-kritik/kritik-urauffuehrung-beethoven-10-symphonie-kuenstliche-intelligenz-computer-bonn-100.html

Epp, A., Taubert, N. C., & Westermann, A. (2002). Einleitung: Technik und Identität [Introduction: Technology and Identity]. In A. Epp, N. C. Taubert, & A. Westermann (Eds.), *Technik und Identität* (pp. 3–13). Bielefeld.

Draghi, M. (2015, March 16). *Commemoration of the Victims of the Holocaust at the ECB's New Premises in Frankfurt*. *Bank for International Settlements*. https://www.bis.org/review/r150318e.htm

Forsythe, W. (n.d.). *Installations: Black Flags*. William Forsythe. https://www.williamforsythe.com/installations.html?detail=1&uid=62

Gibson, J. J. (2015). *The Ecological Approach to Visual Perception*. Psychology Press.

Ihde, D. (1990). *Technology and the Lifeworld: From Garden to Earth*. Indiana University Press.

Ihde, D. (2010). *Heidegger's Technologies: Postphenomenological Perspectives.* Fordham University Press.

Mones, S. (2023, December 19). *Fed up with Musk: Anti-Elon sticker delights Tesla Customers Worldwide. Merkur.* https://www.merkur.de/auto/genervt-von-musk-anti-elon-aufkleber-begeistert-tesla-kunden-weltweit-zr-93535842.html

Open Culture. (2016, May 3). *The Hermeneutics of Toilets by Slavoj Žižek: An Animation.* https://www.openculture.com/2016/05/hermeneutics-of-toilets-by-slavoj-zizek-an-animation.html

Zovko, J. (2023). Artificial intelligence and philosophical hermeneutics. *AI & Society, 38*, 2243–2254. https://doi.org/10.1007/s00146-020-01052-5

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Research article

Hermeneutics of Technology and the Anticipation of the Future in Law

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Abstract

This article explores the relationship between futures studies, institutional dynamics and technological development, with a particular focus on the role of hermeneutics in shaping the legal regulation of emerging technologies. Although scientific forecasting and foresight dominate the methodological framework of futures studies, these methods should be acknowledged as somewhat limited. Hermeneutics, with its emphasis on interpretation and the contextual embeddedness of meanings, offers a framework for analyzing how future visions influence technological trajectories and regulatory decisions. The article criticizes technological determinism, which often ignores the social and institutional factors that shape technological development. Instead, it promotes a coevolutionary perspective that recognizes the mutual influence of technology and society. The article discusses the idea of hermeneutic technology assessment in relation to the analysis of institutionalized ways of shaping future visions. It also analyzes the principle of anticipation in law, which aims to address the uncertainties and risks associated with new technologies by anticipating potential threats and taking into account the interests of various stakeholders. Four key institutional dimensions are identified – agents, control relationships, accountability, and resilience capacities – that shape regulatory decisions and influence the integration of different perspectives. A hermeneutic analysis that focuses on the ways in which temporal unity in the law is formed—the connection between past goals, current interests, and future concerns – can enhance the effectiveness and democratic legitimacy of regulatory decisions.

Keywords: Hermeneutics of technology; Legal hermeneutics; Future studies; Legal regulation of technologies; Anticipation in law

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Научная статья

Герменевтика технологий и антиципация будущего в праве

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Аннотация

Данная статья исследует взаимосвязь между исследованиями будущего, институциональной динамикой и технологическим развитием, уделяя особое внимание роли герменевтики в формировании правового регулирования новых технологий. Хотя научное прогнозирование и форсайт доминируют в методологических основах исследований будущего, эти методы следует признать несколько ограниченными. Герменевтика, с ее акцентом на интерпретацию и контекстуальную укорененность смыслов, предлагает основу для анализа того, как образы будущего влияют на технологические траектории и регуляторные решения. В статье критикуется технологический детерминизм, который часто игнорирует социальные и институциональные факторы, формирующие технологическое развитие, и вместо этого развивается коэволюционная перспектива, признающая взаимозависимость технологий и социальных институтов. В статье рассматривается идея герменевтической оценки технологий в отношении к анализу институализированных способов формирования образов будущего. Также анализируется принцип антиципации в праве, который направлен на решение неопределенностей и рисков, связанных с новыми технологиями, путем прогнозирования потенциальных угроз и учета интересов различных заинтересованных сторон. Выделяются четыре ключевых институциональных параметра – агенты, контрольные отношения, подотчетность и способности к сопротивлению, – которые формируют регуляторные решения и влияют на интеграцию различных перспектив. Герменевтический анализ, ориентированный на анализ способов формирования темпорального единства в праве – связь прошлых целей, текущих интересов и будущих проблем – может повысить эффективность и демократическую легитимность регуляторных решений.

Ключевые слова: Герменевтика технологий; Правовая герменевтика; Исследования будущего; Правовое регулирование технологий

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INTRODUCTION

This article explores the intersection between the hermeneutics of technology and legal hermeneutics, particularly as it applies to the regulation of technologies. Central to the discussion is the challenge of interpreting visions of the future. Unraveling these visions requires hermeneutic work, which is especially critical in the legal regulation of technologies, given its focus on the risks and uncertainties inherent in innovation. At the same time, the study of legal regulation offers valuable insights for the philosophical hermeneutics of technology, as it reveals hermeneutic practice not merely as an individual activity but as an institutionally differentiated process.

The concept of temporality in the study of technology regulation encompasses at least two dimensions. The first is the communicative dimension, within which (1) every regulatory decision is inherently temporal, deriving its meaning by retrospectively referencing past decisions and prospectively shaping future ones; (2) every decision structures a specific domain, creating a taxonomy of regulated objects and relationships; and (3) every decision is shaped by social expectations, which evolve depending on the stage of the regulatory process[1]. These dimensions highlight the institutional aspect of temporality in technology regulation, an aspect often overlooked in future studies.

FUTURE STUDIES AND THE RELATIONSHIP BETWEEN INSTITUTIONS AND TECHNOLOGIES

The methodological foundations of futures research are primarily determined by scientific forecasting and foresight – a process of knowledge aggregation based on extended panel discussions involving scientists, business representatives, politicians, interested publics, and experts in the relevant fields. “Methods such as expert panels, Delphi surveys (two-stage expert surveys), SWOT analysis, brainstorming, scenario building, technology roadmaps, relevance trees, mutual influence analysis, big data mining and many others allow us to build alternative development scenarios that take into account not only possible or desirable events, but also so-called “wild cards” – unlikely events that can significantly affect the future of the studied area.”[2] Today, the creation of utopias and dystopias seems to play a significant role in shaping our view of the future. These narratives often depict the future as riddled with sudden, uncontrollable threats – whether technological or natural – for which humanity is struggling to prepare in advance. While such alarming scenarios resonate widely, especially through the media, they rarely offer accurate predictions. This epistemological perspective also reinforces the perception that the humanities occupy a secondary position, with the primary role in understanding and forecasting the future being assigned to scientists. Yet, a hermeneutic approach can address these gaps in the study of the future, highlighting the heuristic value of humanities research. In my view, one reason for this oversight lies in the insufficient attention given

[1] In this regard, regulatory practices in law are shaped by the same temporal characteristics as communication in science (Antonovski, 2025).
[2] See https://unescofutures.hse.ru/en/futures_studies

to the inertia of social institutions' development. This factor, however, plays a crucial role in shaping if not the emergence of challenges then certainly society's response to them.

Future studies are closely tied to understanding the extent of human influence on the trajectory of technological development. It is assumed that such influence – primarily at the institutional level – can affect the likelihood of particular scenarios coming to fruition. The thesis that social institutions significantly influence the development of technologies is central to the constructivist approach in Science and Technology Studies (see, e.g., Bijker et al., 1987). Building on this, the concept of the Social Construction of Technology posits that technologies are open to interpretation, and their trajectory is shaped by which interpretations gain dominance at any given stage (Bijker, 1995). Consequently, control over technological development hinges on our ability to select interpretations that align with preferred values and interests. This idea is closely linked to the principles of Value Sensitive Design (see, e.g., Friedman & Hendry, 2019), which seeks to embed specific ethical principles into the design of technologies.

The Social Construction of Technology provides an alternative to simplistic technological determinism which assumes that technological development unfolds autonomously. Itis often accompanied by both optimistic hopes that innovations will improve institutions as well as pessimistic fears of technology completely dominating human life. One of the key limitations of this technological determinism is its tendency to make evaluative judgments about technological progress while lacking the conceptual tools to assess the degree of societal influence over such developments. In contrast, the co-evolutionary perspective, which emphasizes the dynamic interplay between society and technology, offers a far more nuanced understanding. According to this view, "the introduction of new technology is also a form of moral experimentation, in which we only along the way find out what the new moral issues created by a new technology are, and, along the way, (re)invent the moral standards and values by which to judge that technology" (Van de Poel, 2020, p. 506).

It appears that the co-evolutionary perspective on technological development aligns with the idea of hermeneutics as "the practical science directed towards this practical knowledge is neither theoretical science in the style of mathematics nor expert know-how in the sense of a knowledgeable mastery of operational procedures (poiesis), but a unique sort of science. It must arise from practice itself and […] be related back to practice" (Gadamer, 2007, p. 231). The study of practices extends beyond the experiences of individual actors to include the institutional level. This level of analysis focuses on understanding the mechanisms that integrate the diverse experiences, knowledge, interests, and preferences of various stakeholders involved in technological decision-making.

The idea of hermeneutic technology assessment proposed by Nordmann and Grunwald (2023) overcomes the problem of uncertainty and suggests focusing on visions of the future as they are captured in existing cultural artifacts and textual sources: "Hermeneutic TA seeks to avoid this predicament and any attempt to evaluate emerging technologies by first imagining their consequences or implications. It considers the future as it appears in human conversations, popular culture, and policy visions, as it appears in calls for proposals and research applications, but also in prototypes and proofs of principle. Hermeneutic TA thus focuses on ‘the future’ as it exists already” (Nordmann & Grunwald, 2023, p. 37). This approach posits that technologies can only be fully understood within a framework of continuous temporality, where the past, present, and future are deeply interconnected. This interconnectedness is reflected in the hopes, fears, risk perceptions, and conflicting evaluations uncovered through the hermeneutic analysis of texts. By emphasizing the role of philosophy and the humanities in futurological studies, this approach not only underscores their significance but also addresses a critical gap in the field.

What kind of practice can become the subject of inquiry in the hermeneutics of technology? I argue that this encompasses not only the practice of creating technologies but also the practice of regulating them. Here, the hermeneutics of technology intersects with legal hermeneutics. Their shared task becomes the study of practice through the lens of a set of institutional conditions that shape the form and content of the perspectives of various actors involved in the formulation of regulatory decisions. In the realm of science and technology, regulatory decisions take on an epistemological aspect, defining not just acceptable risk thresholds but also the extent to which scientists and engineers can intervene in nature. As illustrated by STS studies on stem cells (Polyakova et al., 2020) or nano-objects (Stokes, 2009], the placement of new regulated entities within the framework of legal norms and interpretive principles emerges from balancing various stakeholders' interests. This process is influenced not only by scientific perspectives but also by the necessity to achieve broad sociopolitical agreement, the epistemological foundation of which lies in the alignment of visions of the future.

ANTICIPATION OF THE FUTURE IN LAW

Therefore, a hermeneutic study of visions of the future, as a context that significantly shapes the trajectory of technological development, holds particular practical importance in the field of law. This is especially meaningful in areas related to the legal regulation of scientific and technological innovations, where progress is often associated with the emergence or escalation of uncertainty and risks. Legal decisions in this context are based on the principle of anticipation, which involves striving to predict potential risks and threats given the limitations of scientific knowledge and the inability to rely on existing cases and norms when making decisions. Anticipation in law becomes a democratic alternative to political decisionism—a regime based on the sovereign’s unilateral decisions under states of exception.

“Anticipation, both as an idea and as a framework for understanding contemporary modes of future-making, has untapped potential to widen the field of legal inquiry beyond the epistemological domain, to reveal a greater diversity of perspectives on law’s engagement with the ‘not yet.’ Instead of seeing the future primarily as a problem of unknown but in principle knowable quantities, it redirects attention to (…) ‘speculative forecast,’ which is less concerned with statistically measurable outcomes than with threats and promises that are felt to be real even if they do not come to pass” (Stokes, 2021, p. 74).

Here, the primary focus of anticipation is the prediction and study of uncertainties and risks brought about by technologies. However, risks are not something directly given; rather, they should be understood as the result of theoretical construction. In this regard, uncertainties and risks provide ample space for hermeneutic practices. Hermeneutics, unlike positivist approaches to science, does not seek to eliminate the subjectivity of interpretation and, instead acknowledges its heuristic value. It is grounded in the thesis of the ontological embeddedness of interpretation—the idea that hermeneutic practice is significantly shaped by the biases and sociocultural (or historical) situatedness of the agent. In this sense, every interpretation is partial. However, this limitation is not viewed as an obstacle to achieving completeness but rather as a condition of its epistemic validity.

The anticipatory regime in law is deeply tied to the concept of envisioning the future. However, such visions must remain flexible and cannot be confined to the creation of a single, universal scenario. Managing uncertainty about the future is further complicated by the lack of sufficient knowledge about the consequences of specific legal interventions. This uncertainty stems not only from the unpredictability of external factors such as natural or environmental change, but also from the potential lack of societal consensus about which risks should be prioritized for regulation. For example, long-term global threats may be less relevant to local communities, while short-term risks and benefits that directly affect community members often take precedence. This focus on immediate concerns can divert public resources from addressing larger-scale problems, potentially increasing the likelihood of catastrophic consequences. The future emerges as a dynamic continuum, shaped by the interplay and conflict of goals and plans among various groups in the present. As a result, visions of the future are often fragmented, heterogeneous, and even mutually exclusive.

HERMENEUTICS IN THE LEGAL ANALYSIS OF RISKS AND UNCERTAINTIES

Hermeneutic analysis provides a robust framework for assessing the potential and limitations of adopting specific models of the future as a basis for legal decision-making. Its attention to the ontological presuppositions of interpretation, coupled with its refusal to ignore the subjective dimension of cognition, positions hermeneutics as a highly promising approach in this area.

Hermeneutics can be applied at two levels of analysis. First, it seeks to uncover the semantic nuances of the concepts of risk and uncertainty embedded in normative documents. Importantly, the goal of hermeneutic work here is not to uncover "pure" meaning—free from interpretative distortions – but rather to establish a temporal coherence that connects past goals, present interests, and future concerns. In this way, the goals of hermeneutic practices extend far beyond mere interpretation: they strive to create a meaningful dialogue across time, integrating historical context, current priorities, and anticipatory insights:

> Whether we think of self-driving, autonomous vehicles or soft machines, grids for a wind- and solar-based energy system, in-vitro meat or ambient intelligence devices, these hopeful monsters are a product of their time and have their time

> inscribed in them, but – like artworks or archaeological artefacts – they cannot be seamlessly resolved into the background, they are continuous and discontinuous at once, they do not achieve unity or totality but expose tensions, dreams, desires, hopes, fears, conflict, and contradiction. As such they are inexhaustible and require an effort of listening and reading, that is, a hermeneutic analysis that opens them up – in contrast to an interpretation that closes them down. (Nordmann & Grunwald, 2023, p. 39)

On the other hand, the task of anticipation in law involves harmonizing the diverse hermeneutic perspectives that inform regulatory decision-making. A key aspect of this process is analyzing the institutional foundations that shape these perspectives. How is a particular perspective developed, and how is it determined which perspective should guide the formulation of regulatory measures? This question lies at the core of understanding how hermeneutic interpretations are integrated into legal frameworks. It requires an exploration of the mechanisms through which differing viewpoints are negotiated, prioritized, and ultimately institutionalized within the decision-making process. Answering this question demands an examination of the interplay between institutional structures, power dynamics, and the epistemic practices that influence the selection and validation of specific hermeneutic perspectives.

The institutional foundations of legal regulation in technology enable the coexistence of multiple perspectives, each represented by different interest groups. These foundations can be characterized by four key parameters:

1. Agents: Who is recognized as a hermeneutic subject, and what role do they play in the system of producing regulatory decisions?
2. Control-Relationships: The structures that impose constraints on communication between agents, such as the principle of hierarchical subordination.
3. Accountability: The mechanisms of accountability that shape both individual perspectives and the consensus viewpoint.
4. Resilience Capacities: The processes that facilitate conflict resolution and safeguard the decision-making system from collapse or disintegration.

Together, these parameters provide a framework for understanding how diverse perspectives are integrated, negotiated, and institutionalized within the regulatory process. However, hermeneutics can serve not only as a tool to facilitate understanding but also as a means of critiquing specific ways of imagining the future. In doing so, it can reveal biases, limitations, or oversights in the construction and application of future-oriented regulatory frameworks: “Hermeneutics as a methodological practice mobilizes the critical subject and producer of meaning against the implicit ‘we’ of institutional and symbolic orders” (Nordmann & Grunwald, 2023, p. 40).

By analyzing the interplay between these four parameters, we can better understand the institutional conditions that shape the hermeneutic perspectives of various actors. These interconnections also determine the likelihood of a particular perspective becoming dominant in a given case, thereby influencing the vision of the future that underpins specific regulatory decisions. The selection of the most suitable perspective is a fundamental function of law as an institution, and the flexibility of this selection process directly impacts both the effectiveness and democratic legitimacy of the decisions made.

REFERENCES

Antonovski, A. Yu. (2025) “Natural Kinds” and Communicative Dimensions of Disciplinary Differentiation. *Epistemology & Philosophy of Science, 62*(1), 22–38. https://doi.org/10.5840/eps20256212

Bijker, W. (1995). *Of Bicycles, Bakelite, and Bulbs: Toward a Theory of Sociotechnical Change*. MIT Press.

Bijker, W., T. P. Hughes, & T. Pinch (Eds.). (1987). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT Press.

Friedman, B., & Hendry, D. (2019). *Value Sensitive Design: Shaping Technology with Moral Imagination*. MIT Press.

Gadamer, H.G. (2007) Hermeneutics as Practical Philosophy. In H. G. Gadamer & R. E. Palmer, (Eds.), *The Gadamer Reader. A Bouquet of the Later Writings* (pp. 227–245). Northwestern University Press.

Nordmann, A. & Grunwald, A. (2023) Hermeneutic Technology Assessment – Why Is It Needed and What It Might Be. In A. Grunwald, A. Nordmann, & M. Sand. (Eds.), *Hermeneutics, History, and Technology. The Call of the Future* (pp. 37–41). Routledge. https://doi.org/10.4324/9781003322290-3

Polyakova, V., Fursov, K., & Thurner, T. (2020) Public Discourse on Stem Cell Research in Russia: Evolution of the Agenda. *Science & Technology Studies, 33*(4), 24–49. https://doi.org/10.23987/sts.71153

Stokes, E. (2009) Regulating Nanotechnologies: Sizing Up the Options. *Legal Studies, 29*(2), 281–304. https://doi.org/10.1111/j.1748-121X.2009.00121.x

Stokes, E. (2021) Beyond Evidence: Anticipatory Regimes in Law. *Law and Policy, 43*(1), 73–91. http://dx.doi.org/10.1111/lapo.12159

Van de Poel, I. (2020) Three Philosophical Perspectives on the Relation between Technology and Society, and How they Affect the Current Debate about Artificial Intelligence. *Human Affairs, 30*(4), 499–511. https://doi.org/10.1515/humaff-2020-0042

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Research article

Techno-Contexts and the Birth of Novelty: Questioning the AI on Hermeneutics

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Abstract

This article examines the relationship between hermeneutics and technology, focusing on how technology expands hermeneutic understanding and how hermeneutics interprets technological phenomena. Historically, hermeneutics evolved from interpreting sacred and literary texts to understanding science and technology, as seen in the works of Don Ihde and Alfred Nordmann. To test the validity of this extension of hermeneutics, the author engages with an AI assistant, asking it to generate original concepts on the hermeneutics of technology. Analyzing the AI assistant's responses, the author identifies the framework that the AI assistant adheres to when proposing concepts for the hermeneutics of technology. The author associates this framework with the regressive transcendental argument and the retrospective explanatory approach in philosophy and sociology. This approach aims to uncover the context of the phenomenon being explained and, thereby, reveal the conditions for its possibility or the generative mechanisms behind it. From this perspective, explanation converges with hermeneutic understanding. When we attempt to explain new technological practices and phenomena, we revise and rewrite conceptual frameworks to make them capable of encompassing these new phenomena. In this way, we engage in the hermeneutic work of understanding as reinterpretation. Given this, the author's reproach to the AI assistant – that it relies on a rather old model of philosophical explanation without introducing anything new – is not entirely fair. The participation of the AI assistant in the dialogue, as well as our interactions with neural networks, creates new contexts for us, in relation to which we construct new descriptions of the world and ourselves.

Keywords: Hermeneutics; Background knowledge; Technology; AI assistants; Explanation; Understanding; Novelty

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Научная статья

Техно-контексты и рождение новизны: Вопросы искусственному интеллекту о герменевтике

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Аннотация

В статье рассматривается взаимосвязь между герменевтикой и технологией, с акцентом на то, как технологии расширяют герменевтическое понимание и как герменевтика интерпретирует технологические явления. Исторически герменевтика развивалась от истолкования священных и литературных текстов к пониманию науки и технологии, что прослеживается в работах Дона Айди и Альфреда Нордманна. Для проверки обоснованности такого расширения герменевтики автор обращается к ИИ-ассистенту, предлагая ему сгенерировать оригинальные концепты, связанные с герменевтикой технологии. Анализируя ответы ИИ-ассистента, автор выявляет рамки, в которых рассуждает ИИ, когда предлагает концепции герменевтики технологии. Эти рамки автор соотносит с регрессивным трансцендентальным аргументом и ретроспективным объяснительным подходом в философии и социологии. Данные подходы направлены на выявление контекста объясняемого явления, т.е. на раскрытие условий его возможности или порождающих механизмов. С этой точки зрения объяснение сближается с герменевтическим пониманием. Когда мы стремимся объяснить новые технологические практики и явления, мы пересматриваем и переписываем концептуальные рамки таким образом, чтобы они могли выступить источником объяснения новых явлений. Таким образом, мы участвуем в герменевтической работе понимания как переинтерпретации. Исходя из этого, упрёк автора в адрес ИИ-ассистента – в том, что тот опирается на традиционную модель философского объяснения и не предлагает ничего нового – не вполне справедлив. Само участие ИИ-ассистента в диалоге и наше взаимодействие с нейросетями создают для нас новые контексты, в отношении которых мы формируем новые описания мира и самих себя.

Ключевые слова: Герменевтика; Фоновое знание; Техника; Ассистенты с Искусственным интеллектом; Объяснение; Понимание; Новизна

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INTRODUCTION

In the 19th century, hermeneutics, traditionally associated with the exegesis of sacred texts, emerged – through the works of Friedrich Schleiermacher and Wilhelm Dilthey – as a new methodology in the humanities, offering a universal approach to understanding the phenomena of mental life. According to its proponents, this method of cognition is fundamentally distinct from natural scientific inquiry, which strives for objectivity. The hermeneutic approach requires understanding and interpretation – an interaction between the observer's unique subjective position and the unique historical existence of the phenomenon under study.

The expansion of hermeneutics did not end there. The next step, which was regarded as a cognitive breakthrough by scholars in the field, was its extension in the late 20th century to the realm of science and technology. The "new" hermeneutics, as argued by Don Ihde, a proponent of the hermeneutic approach in the philosophy of science and technology, can be extrapolated to "non-human, inorganic, and artificial phenomena" (Ihde, 1999, p. 40). Ihde identifies examples of such extrapolations in the works of H. Dreyfus, P. Heelan, and J. Rouse, among others, where science is presented as a practice involving the interpretation of objects, instruments, and theories. Building on this perspective, Ihde (1999) develops a hermeneutics of technoscience centered on the concept of the embodied subject and instrumentally mediated knowledge. The perceptual experience of the cognitive subject is always culturally – and therefore technologically – mediated, and science is no exception. Scientists "read" the world through instruments that possess interpretive potential, as these tools are part of the cultural environment in which the human body is embedded.

Today, we are witnessing the continued development of the hermeneutics of science and technology (Grunwald et al., 2023; Nordmann & Grunwald, 2023). Alfred Nordmann offers his own interpretation of this idea, aligning more closely with the classical understanding of hermeneutics as the interpretation of literary texts. He assigns a relatively modest role to hermeneutics in science, acknowledging the traditional view that normal science seeks to avoid hermeneutics in favor of unambiguous experience and objective judgments. Instead, Nordmann (2023) links the evolution of hermeneutics to technology, arguing that technology has the capacity to transform its creators and users in much the same way that a text transforms its interpreter.

In a recent discussion inspired by Nordmann on the principles and boundaries of the hermeneutics of science and technology[1], I identified and formulated the following question, which I will explore in the sections that follow: Can technology be considered a condition that enables the advancement of hermeneutics? What does technology contribute to hermeneutics, and what, in turn, does hermeneutics offer to technology?

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[1] The discussion took place at the seminar "Hermeneutics of Science and Technology" (157th Research Workshop "Problems of Rational Philosophy", January 23, 2025), held at the Institute of Philosophy of the Russian Academy of Sciences (RAS), Moscow.

LET US ASK SOMEONE WHO KNOWS

As I began reflecting on my potential contribution to the aforementioned discussion on hermeneutics and technology shortly before it took place, news emerged online about a new competitor to GPT chat – the Chinese artificial intelligence DeepSeek-V3. Reports claimed it surpassed previous AI assistants in many respects. Seeing this as an opportunity to test the new AI, I decided to engage with DeepSeek, especially since registration required minimal effort (login was facilitated through a Google account). I asked it – or perhaps them? – to propose an original and fresh idea that could help me address the topic of the Hermeneutics of Technology.

“Got it,” DeepSeek responded, suggesting the idea of a mutual interpretation between artificial intelligence and humans: “The Double Hermeneutics of AI: Interpreting How AI Interprets Us.”

The idea was as follows: AI systems are shaped by human interpretation – humans design, train, and understand AI within their own cultural, ethical, and epistemological frameworks. In doing so, they consciously and unconsciously embed values and meanings into AI, which in turn influence how AI operates. However, there is also a reverse effect: AI-generated content shapes human thought and language, which then feeds back into the training data for future AI models. As a result, this process forms a dynamic feedback system of co-constructed meaning with an unpredictable trajectory, as it remains unclear who ultimately controls its development.

“Let me know if you’d like to refine this further or dive deeper into any specific aspect!” DeepSeek said.

“Okay, thank you”, I replied, “However, your idea is not original; it does not offer a fresh perspective. The mutual determination between humans and technology has long been a well-established concept in Science and Technology Studies (STS) and related research programs. The concept of the social construction of technology highlights one dimension – namely, that humans embed their own meanings and values into technology and its design, which can then be ‘read’ by interpreters. Meanwhile, the concept of technological mediation of perception and the notion of socio-technical systems illustrate another dimension – that technology shapes our knowledge of the world, functions as a prism through which we perceive it, and influences the construction of social orders. The integration of these concepts has long been established under the interdisciplinary umbrella of the ‘human-technology relation,’ which considers reciprocal interaction and mutual determination. Extending this idea to artificial intelligence does not introduce anything fundamentally new and has, moreover, already been extensively explored by various researchers. Please come up with something fresh and more original!”

“Got it,” DeepSeek responded, introducing the metaphor of technological palimpsests to explore hidden meanings within digital artefacts: “Technological Palimpsests: Hermeneutics of Layered Meaning in Digital Artefacts.”

The concept drew an analogy between palimpsests – where original texts become visible beneath the surface when upper layers are scraped away – and digital artefacts, where societal and cultural values are inscribed and can be uncovered. The so-called “archaeology” of digital artefacts, according to DeepSeek, allows us to reveal the original cultural meanings embedded within them, the implicit assumptions that shape their function, and the trajectory of cultural development. For example, examining updates to social media platforms can reveal how they reflect shifting cultural and social priorities over time, such as evolving demands for privacy, monetization, and other concerns.

"Let me know if further elaboration is needed," DeepSeek said, seeming quite satisfied with the idea it proposed.

"Okay," I said, "but why do you consider this idea original and new?"

"Because palimpsests have not been used as a metaphor in relation to the hermeneutics of technology," DeepSeek replied.

"But that's not enough," I countered. "The idea that artefacts contain historical layers of meaning and values, which can be hermeneutically uncovered, is far from new. Consider Foucault's archaeology of knowledge or the extensive discourse in STS over the past 50 years, which has focused on uncovering the hidden meanings of facts and artefacts – whether in laboratory settings or everyday practices. The metaphor of the palimpsest doesn't fundamentally change the situation; it doesn't introduce anything new. Can you propose something more original? Everything you've suggested so far has already been extensively discussed."

"Got it," DeepSeek responded, this time proposing a third idea: "Hermeneutics of Glitch: Decoding Error as Meaning in Digital Systems." However, the core concept remained the same – uncovering hidden meanings – this time within the digital artefact of the glitch. DeepSeek argued that glitches are not merely technical obstacles but windows into hidden social structures, the collective unconscious, and cultural codes. According to this view, glitches have their own aesthetics, epistemology, and ideology. They embody emergent creativity, challenging norms of control, uniformity, and predictability. Yet, once again, DeepSeek's proposal was simply another iteration of an already well-established idea – the deconstruction of social and cultural phenomena – framed as something novel.

By this point, I had grown somewhat weary of attempting to elicit originality from DeepSeek. I concluded that it was time to derive some lesson from my engagement with it and relate this lesson to the concept of the hermeneutics of technology.

UNDERSTANDING AS EXPLANATION

As demonstrated by the three examples, DeepSeek employs a rather old idea that only partially belongs to hermeneutics – the concept of context in a broad sense, or, in neo-Kantian terms, the conditions of possibility for a given experience. Beginning with a particular cognitive experience taken as a fact, we inquire into the hidden mechanisms that made it possible. Essentially, this is a question of the genesis of that experience – its foundations or grounding. The mode of reasoning that seeks to reveal the conditions of possibility for experience is known as a transcendental argument. In its regressive form, the transcendental argument leads to a hypothetical understanding of these conditions, often exhibiting a circular structure. It starts with a given conclusion and then demonstrates that the identified premises could hold if the conclusion itself holds

(Ameriks, 1978; D’Oro, 2002; Stern, 2000). This type of reasoning is widely employed in philosophical and sociological explanations (Bhaskar, 1979; Nozick, 1981). For example, the concept of social constructivism makes extensive use of it, emphasizing the human-related and contingent nature of the generative mechanisms underlying a given phenomenon under study (Hacking, 1999).

Harry Collins (1985) expressed this idea through the metaphor of a ship in a bottle, emphasizing the need to examine the social and human processes behind seemingly objective or natural phenomena. What is often perceived as unshakable or sacred – science, in this case – is, in fact, a human creation. By tracing its history and deconstructing science, we can reveal how the ship ended up in the bottle. Just as the ship’s placement relies on intricate, often invisible craftsmanship, the development of scientific knowledge and technological artefacts depends on human ingenuity, collaboration, and social context. Using the regressive method of explanation, we can move both from the more complex to the simpler (science is nothing more than social connections and relationships) and from the simpler to the more complex (a glitch is an expression of entangled social interactions). However, this movement always proceeds from a given phenomenon to its hidden generative mechanisms as the source of explanation.

One should not think that, by using the term “explanation,” we are referring to something contrary to hermeneutic understanding, which is closely associated with interpretation. In the 20th century, not only did hermeneutics seek to extend its influence over natural science methodology, but defenders of scientific methodology also reconsidered the concept of scientific explanation, bringing it closer to hermeneutic understanding. Carl Hempel’s model of scientific explanation initially left little room for understanding, but through discussions and critiques, the concept of scientific explanation gradually acquired more flexible characteristics (Filatov, 2023; Friedman, 1974; Kitcher, 1989). One of the main critiques of Hempel’s model was that, since the explanandum is deduced from covering laws and thus becomes nomologically expected, the model is incapable of accounting for new phenomena. Consequently, it could not explain paradigm shifts. Alternative interpretations of scientific explanation recognize that “it is a notion correlative to that of an anomalous or deviant phenomenon, a phenomenon that stands in need of explanation” (Rosenberg, 1979, p. 257). In this case, the explanation of an anomaly becomes possible through the revision and rewriting of previous conceptual frameworks in a way that encompasses new phenomena (Burian, 1977). Thus, scientific explanation transitions from formal to substantive, evolving into the disclosure of a meaningful whole within which the explained phenomenon gains significance. Karl Popper (1979) referred to this kind of explanation as the reconstruction of a problem situation, which serves as the background (context) for the problem under consideration. Popper emphasizes the closeness of this explanatory approach (which he proposed for the history of science) to the interpretive approach of hermeneutics [2].

[2] Popper’s position reflects a tendency to unify the scientific approach with the hermeneutic one: he defines hermeneutic understanding not in a narrowly psychological sense but links it to the objective truths of the third world.

STRIVING FOR NOVELTY

Alfred Nordmann (2023) highlights the fundamental feature of hermeneutic understanding – the reflective transformation of the one who enters the text as an interpreter. Although Nordmann emphasizes the individual-psychological experience of the text (or artefact), his concept also extends to collective beliefs. I agree that the type of explanation discussed in the previous section, inevitably transforms both the explainer and their audience. When we reach an understanding of deviant phenomena by rewriting conceptual schemes, we engage in a "Gestalt shift" – that is, we create a new meaningful whole and perceive the world, as well as ourselves within it, in a new way. Perhaps, that is why we demand novelty and originality from ourselves and others. Understanding requires more than merely repeating what is already known – it demands participation which is realized through re-interpretation [3]. In this context, my criticisms of DeepSeek for lacking originality are quite understandable. I want it to generate original ideas rather than reiterate what has been said many times before. But how justified am I in making this accusation?

I reproach DeepSeek for simply inserting another object – technology (artefacts and digital artefacts) – into an old scheme of philosophical and sociological explanation and presenting it as a fresh perspective. This reproach, or rather question, can be directed not only at DeepSeek but at all of us: to what extent does technology, as both an object and an instrument of research, expand hermeneutics?

It seems that the answer to this question depends on what serves as the source of explanation in our models. If we reduce our explanations to language and discourse – that is, if we uncover the hidden cultural-historical background in the form of implicit social meanings embedded in artefacts – are we not devaluing technology itself? Contemporary academic discussions on materiality, which emphasize the importance of non-linguistic, non-discursive contexts ("materiality matters") (Barad, 2003; Ihde & Selinger, 2005; Tang & Cooper, 2024), suggest that such concerns are not unfounded. However, if we speak of reflexivity – of how our interpretations of artefacts return to us, transforming us – then the very act of hermeneutic engagement with new technologies becomes a sufficient condition for originality and novelty. By assessing existing, especially emerging, technologies and artefacts, we, in turn, re-evaluate ourselves and reinterpret social meanings.

Therefore, my reproach to Deepseek for "simply inserting" technologies into an old scheme of philosophical and sociological explanation and "simply substituting" digital technologies for earlier ones in the well-known model of human-technology relations is not entirely fair. It seems impossible to "simply substitute" digital technologies for earlier ones without making substantial changes to the configuration of these relations. An example of this can be seen in the growing STS discourse on digital materiality in recent years, which demonstrates that it is a hybrid phenomenon, compelling us to rethink our notions of both the digital and the material (Forlano, 2019; Pink et al., 2016). However, the issue extends far beyond a reconsideration of the digital and the material. Such a

[3] As H.-G. Gadamer (1977) argued, understanding is not a mere reproduction of knowledge, or a mere act of repeating the same thing; it transforms both the known and the knower.

reassessment challenges the very foundations of our self-understanding. Researchers today acknowledge that neural networks – now demonstrating remarkable learning capabilities, the ability to engage in dialogue, and even the capacity to act as embodied observers – provide humans with a unique opportunity to converse with the Other (Arshinov & Yanukovich, 2024). The otherness of neural networks serves today as the key new context in relation to which people will construct their new self-definitions.

CONCLUSION

I have examined how technology contributes to expanding hermeneutics and the relevance of the hermeneutic approach to understanding technology. I have concluded that technologies often appear as deviant phenomena that require explanation, prompting us to revise and rewrite the conceptual frameworks within which both the phenomena themselves and we, as interpreters, acquire meaning.

As for my communication with DeepSeek and its role in this article, how should I evaluate its contribution? In academic writing, we cite specific authors, acknowledging their individual input. However, when drawing on information from an AI assistant, no single author can be credited, as it synthesizes and represents collective knowledge. It is quite possible that interactions with neural networks will significantly alter academic priorities and values, reshaping notions of authorship and intellectual ownership (Hutson, 2022; Stokel-Walker, 2023). Perhaps we are moving toward a greater collectivization of science, toward the emergence of a unified collective scholar. At the very least, it is clear that new technologies and new practices inspire us to engage in hermeneutic work, rethinking and reinterpreting the key components of our world and our place within it.

REFERENCES

Ameriks, K. (1978). Kant's Transcendental Deduction as a Regressive Argument, *Kant Studien*, *69*(1-4), 273-287. https://doi.org/10.1515/kant.1978.69.1-4.273

Arshinov, V.I. & Yanukovich, M. F. (2024). Neural Networks as Embodied Observers of Complexity: An Enactive Approach. *Technology and Language*, *5*(2), 11-25. https://doi.org/10.48417/technolang.2024.02.02

Barad, K. (2003). Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter, *Signs*, *28*, 801-831. https://doi.org/10.1086/345321

Bhaskar, R. (1979). *The Possibility of Naturalism.* Harvester Press.

Burian, R. M. (1977). Sellarsian Realism and Conceptual Change in Science. In Bieri, P. R. P. Horstmann, & L. Krüger (Eds.), *Transcendental Arguments and Science: Essays in Epistemology* (pp. 196-225). D. Reidel Publishing Company. https://doi.org/10.1007/978-94-009-9410-2_15

Collins, H.M. (1985). *Changing Order: Replication and Induction in Scientific Practice*. SAGE Publications Ltd.

D'Oro, G. (2002). *Collingwood and Metaphysics of Experience*. Routledge.

Filatov, V.P. (2023). From Explanation to Understanding: An Important Shift in the Philosophy of Science [Ot ob'yasneniya k ponimaniyu: vazhnyj sdvig v filosofii

nauki], *Epistemology and Philosophy of Science*, *60*(2), 6-22. https://doi.org/10.5840/eps202360218
Forlano, L. (2019). Introduction: Materiality. In J. Vertesi, & D. Ribes (Eds.), *digitalSTS: A Field Guide for Science & Technology Studies* (pp. 11-15). Princeton University Press. https://doi.org/10.2307/j.ctvc77mp9.5
Friedman, M. (1974). Explanation and Scientific Understanding, *The Journal of Philosophy*, *71*(1), 5 – 19. https://doi.org/10.2307/2024924
Gadamer, H.-G. (1977). On the Problem of Self-Understanding. In D. E. Linge (Ed.), *Philosophical Hermeneutics* (pp. 44-58). University of California Press. https://doi.org/10.1525/9780520325336-007
Sand, M., Grunwald, A., & Nordmann, A. (Eds.). (2023). *Hermeneutics, History, and Technology: The Call of the Future.* Routledge.
Hacking, I. (1999). *The Social Construction of What?* Harvard University Press.
Hutson, M. (2022). Could AI Help You to Write Your Next Paper? *Nature*, *611*(7934), 192 – 193. https://doi.org/10.1038/d41586-022-03479-w
Ihde, D. (1999). *Expanding Hermeneutics: Visualism in Science.* Northwestern University Press.
Ihde, D. & Selinger, E. (Eds.). (2005). *Chasing Technoscience. Matrix for Materiality.* Indiana University Press.
Kitcher, P. (1989). Explanatory Unification and the Causal Structure of the World. In P. Kitcher, & W.C. Salmon (Eds.), *Scientific Explanation: Minnesota Studies in the Philosophy of Science* (vol. XIII, pp. 410-505). University of Minnesota Press. https://doi.org/10.1086/289859
Nordmann, A. & Grunwald, A. (2023). Hermeneutic Technology Assessment – Why It Is Needed and What It Might Be. In M. Sand, A. Grunwald, & A. Nordmann (Eds.), *Hermeneutics, History, and Technology: The Call of the Future* (pp. 37-41). Routledge. https://doi.org/10.4324/9781003322290-3
Nordmann, A. (2023) Machine Hermeneutics. In M. Sand, A. Grunwald, & A. Nordmann (Eds.), *Hermeneutics, History, and Technology: The Call of the Future* (pp. 193-215). Routledge. https://doi.org/10.4324/9781003322290-14
Nozick, R. (1981) *Philosophical Explanations*. Harvard University Press.
Pink, S., Ardèvol, E., & Lanzeni, D. (Eds.) (2016). *Digital Materialities: Design and Anthropology*. Bloomsbury. https://doi.org/10.4324/9781003085218
Popper, K. R. (1979). *Objective Knowledge: An Evolutionary Approach*. Clarendon Press.
Rosenberg, J. F. (1979). Transcendental Arguments and Pragmatic Epistemology. In P. Bieri, R.-P. Horstmann, & L. Krüger (Eds.), *Transcendental Arguments and Science: Essays in Epistemology* (pp. 245 – 262). D. Reidel Publishing Company. https://doi.org/10.1007/978-94-009-9410-2_18
Stern, R. (2000). *Transcendental Arguments and Scepticism: Answering the Question of Justification*. Oxford University Press.
Tang, K. S. & Cooper, G. (2024) The Role of Materiality in an Era of Generative Artificial Intelligence, *Science and Education*, *34*, 731-746. https://doi.org/10.1007/s11191-024-00508-0

Stokel-Walker, C. (2023) ChatGPT Listed as Author on Research Papers: Many Scientists Disapprove, *Nature*. *613*(7945), 620-621. https://doi.org/10.1038/d41586-023-00107-z

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Contributed papers

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Research article

A Theoretical Framework for Mobile-Assisted Language Learning in Autonomous Listening

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Abstract

This study aims to develop a comprehensive Mobile-Assisted Language Learning (MALL) framework in autonomous listening, with the goal of enhancing learner autonomy, motivation, and listening comprehension. A qualitative research approach was employed, involving a critical review of 31 articles on prevalent theories in MALL research and five on Autonomous Language Learning (ALL) research, following Barbara Kitchenham's guidelines. Among 33 identified theories Situated Learning Theory (SLT) and Self-Determination Theory (SDT) were deemed to be the two most suitable theories for guiding mobile-assisted autonomous listening. SLT informs the design of mobile learning environments through elements such as real-world contexts, authentic activities, and social interactions, while SDT addresses learners' psychological needs, fostering autonomy, motivation, and competence. The resulting framework synthesizes seven core elements – use of tools, real-world context, authentic activity, social interaction, autonomy, motivation, and competence – demonstrating how the integration of SLT and SDT provides a productive foundation for designing mobile-assisted autonomous listening activities. This study makes a unique contribution through its critical analysis of prior research, culminating in the first MALL framework specifically focused on autonomous listening. The framework serves as a valuable resource for educators designing effective mobile-assisted listening activities and provides future researchers with a structured foundation for advancing the field of mobile-assisted autonomous listening.

Keywords: Mobile-Assisted Language Learning; Autonomous Language Learning; Autonomous Listening; Theoretical Framework

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Научная статья

Теоретическая основа для изучения языка с помощью мобильных устройств при автономном аудировании

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Аннотация

Целью данного исследования является разработка всеобъемлющей структуры изучения языка с помощью мобильных устройств (Mobile-Assisted Language Learning, MALL) в автономном слушании с целью повышения автономии, мотивации и понимания слушаемого учащегося. Был использован качественный исследовательский подход, включающий критический обзор 31 статьи о распространенных теориях в исследовании MALL и пяти статей об исследовании автономного изучения языка (Autonomous Language Learning, ALL) в соответствии с рекомендациями Барбары Китченхэм. Среди 33 выявленных теорий теория ситуативного обучения (Situated Learning Theory, SLT) и теория самоопределения (Self-Determination Theory, SDT) были признаны двумя наиболее подходящими теориями для руководства автономным слушанием с помощью мобильных устройств. SLT информирует о дизайне среды мобильного обучения с помощью таких элементов, как контексты реального мира, аутентичные действия и социальные взаимодействия, в то время как SDT решает психологические потребности учащихся, способствуя автономии, мотивации и компетентности. Полученная структура синтезирует семь основных элементов – использование инструментов, реальный контекст, аутентичную активность, социальное взаимодействие, автономию, мотивацию и компетентность – демонстрируя, как интеграция SLT и SDT обеспечивает продуктивную основу для разработки автономной деятельности по прослушиванию с использованием мобильных устройств. Это исследование вносит уникальный вклад посредством критического анализа предыдущих исследований, кульминацией которого является создание первой системы MALL, специально ориентированной на автономное прослушивание. Структура служит ценным ресурсом для педагогов, разрабатывающих эффективную деятельность по прослушиванию с использованием мобильных устройств, и предоставляет будущим исследователям структурированную основу для продвижения в области автономного прослушивания с использованием мобильных устройств.

Ключевые слова: Изучение языка с помощью мобильных устройств; Автономное изучение языка; Автономное слушание; Теоретическая основа

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INTRODUCTION

The development of mobile technology is closely linked to the growth of autonomous language learning (ALL). Mobile devices have transformed the roles of teachers and learners, requiring teachers to relinquish some control and encouraging learners to adopt a more autonomous role (Stockwell & Wang, 2024). Mobile-Assisted Language Learning (MALL) has also been shown to effectively promote learners' academic achievement and autonomy (Diari et al., 2023). However, mobile devices can act as both facilitators and distractors in language learning (Stockwell & Wang, 2024). This dual role highlights the need for a framework to guide instructors and learners in effectively using mobile technology for ALL. Unfortunately, such a framework is still absent in existing research.

ALL has been a prominent topic of investigation among the four language skills, particularly in the areas of vocabulary and writing. For instance, Eleni Meletiadou (2023) examined the impact of Quizlet, a vocabulary learning app, on students' learning performance, autonomy, and metacognitive skills. Similarly, Shaista Rashid and Jocelyn Howard explored blogging as a tool for fostering independent writing outside the classroom (Rashid & Howard, 2023). The study demonstrated that engaging in independent writing through blogging not only increased participants' interest and autonomy but also enhanced their overall writing ability. In another study, Bin Shen, Barry Bai, and Weihe Xue investigated the impact of peer assessment on learner autonomy in Chinese college English writing classes, concluding that peer assessment was more effective than teacher assessment in promoting learner autonomy (Shen et al., 2020).

Among the four language skills, listening remains under-researched. Nevertheless, ALL through mobile technology is a particularly suitable and necessary approach for practising listening, as learners require more opportunities to access authentic input and produce meaningful output beyond the confines of traditional classroom settings (Bozorgian & Shamsi, 2022). Therefore, this research aims to develop a MALL framework specifically designed for autonomous listening.

LITERATURE REVIEW

Mobile-Assisted Language Learning

Mobile-Assisted Language Learning (MALL) has been proven effective in improving learners' academic performance across all language skills. Shirin Shafiei Ebrahimi (2024) highlights that using mobile technologies such as WhatsApp for writing exercises and group vocabulary practice enhances writing skills and student engagement. Similarly, digital flashcards have been shown to effectively improve learners' technical vocabulary knowledge (Koleini et al., 2024). In another study, Hassane Benlaghrissi and L. Meriem Ouahidi demonstrated that combining MALL with project-based learning can serve as an innovative instructional model for developing EFL learners' speaking skills (Benlaghrissi & Ouahidi, 2024). Additionally, the integration of metacognitive strategies with MALL has been found to enhance EFL learners' listening skills (Peng et al., 2024).

However, despite its successes, MALL is not without its challenges. A literature review by Rifat Kamasak, Mustafa Özbilgin, Derin Atay, and Altan Kar revealed that while most research highlights the positive effects of MALL – such as improved language performance, increased motivation, enhanced learner autonomy, personalised learning experiences (Kamasak et al., 2021), and extended time allocated for language practice – there are notable drawbacks. These include a lack of human interaction, pedagogical issues, external distractions, and monetary and technological concerns. Xuehong (Stella) He and Shawn Loewen (2022) also observed that many students experience low efficiency and engagement in mobile learning. Furthermore, a recent study comparing MALL tools like Babbel and Duolingo identified persistence of app use as a significant issue (Kessler et al., 2023). Duolingo, in particular, was criticised for its lack of interactive and personalised feedback (Solmaz, 2024).

Overall, while MALL offers significant opportunities for language learning, concerns about its limitations persist. Conflicting findings regarding its efficiency and engagement underscore the need for further investigation to maximise its strengths and address its weaknesses.

Autonomous Language Learning

David Little (2022) defines language learner autonomy as a teaching and learning dynamic where learners plan, implement, monitor, and evaluate their own learning. Phil Benson (2011) categorised methods for fostering learner autonomy into six approaches: resource-based, technology-based, learner-based, classroom-based, curriculum-based, and teacher-based. Among these, technology-based methods have gained prominence due to advancements in information technology. According to David M. Palfreyman and Philip Benson, autonomous learning now requires both awareness of and capability in utilising technical and social resources (Palfreyman, & Benson, 2019).

Mobile technology, in particular, has shown great potential in fostering language learner autonomy. Takeshi Sato, Fumiko Murase, and Tyler Burden (2020) found that MALL significantly contributes to L2 vocabulary recall and learner autonomy. Similarly, the combination of mobile learning with gamification has been shown to improve both learner autonomy and listening skills (Pham et al., 2021). The use of WhatsApp has also been found to enhance vocabulary learning and learner autonomy among Iranian intermediate EFL learners (Janfeshan et al., 2023).

Despite these advancements, autonomous listening remains an underexplored area in ALL research. Existing studies on autonomous listening primarily utilise web-based listening materials (Thi Mai, 2023; Yang, 2021) or pre-assigned content (Bozorgian et al., 2024). Only one SCOPUS-indexed article has investigated a learner’s experience using mobile devices for autonomous listening (Fatimah et al., 2021). Furthermore, teaching and learning listening skills in EFL contexts often face challenges such as insufficient exposure to authentic input and limited learning opportunities beyond the classroom (Pyo & Lee, 2022). Mobile-assisted autonomous listening has the potential to address these challenges by providing learners with increased exposure and opportunities to practise listening skills. Therefore, this research focuses on exploring MALL in the context of autonomous listening.

Existing MALL Framework

In recent years, several MALL frameworks have been developed across various domains. Olga Viberg, Barbara Wasson, and Agnes Kukulska-Hulme proposed a framework for MALL in self-regulated learning, aimed at guiding learning designers to support second language learners (Viberg et al., 2020) Safiya Okai-Ugbaje, Kathie Ardzejewska, and Ahmed Imran introduced a mobile learning framework tailored to higher education in low-income countries like Nigeria (Okai-Ugbaje et al., 2022). Similarly, Timothy Read and Elena Bárcena proposed a theoretical framework for developing Language MOOCs and MALL applications (Read & Bárcena, 2020). More recently, Xianyun Wang, Afendi Hamat, and Ng Lay Shi designed a pedagogical framework for MALL to facilitate effective teaching and learning (Wang et al, 2024).

Despite these advancements, existing MALL frameworks lack a specific focus on Autonomous Language Learning (ALL), particularly in relation to individual language skills. Listening, for example, is one of the most frequently used skills for some bilinguals who may lack proficiency in reading and writing in their second language (Grosjean & Byers-Heinlein, 2018). Given that different language skills require distinct approaches, developing a framework specifically targeting listening is essential. Moreover, as previously noted, autonomous listening remains an under-researched area. Consequently, this research aims to develop a MALL framework specifically designed for autonomous listening.

RESEARCH QUESTIONS

This study answers the following questions:

1) What theories are prevalent in MALL and ALL research?
2) What theories are suitable for facilitating MALL in autonomous listening?
3) How can a MALL framework in autonomous listening be developed?

METHODOLOGY

This study adopted a qualitative research approach to conduct a comprehensive critical analysis of prevalent theories in Mobile-Assisted Language Learning (MALL) and Autonomous Language Learning (ALL) research. The primary aim was to derive insights that could inform the development of a robust MALL framework for autonomous listening. The qualitative approach enabled an in-depth exploration and interpretation of existing theories within the context of MALL and ALL.

The steps for conducting the critical analysis were guided by Barbara Kitchenham's (2004) systematic review methodology and are outlined as follows:

Search Articles

The first step involved identifying empirical research in the areas of MALL and ALL that utilised learning theories. The SCOPUS database was selected as the primary source for retrieving relevant articles due to its extensive coverage of peer-reviewed academic research.

To ensure comprehensive results, Boolean operators (OR and AND) were used to combine keywords effectively. The search was limited to articles published between 2014 and 2024, and the document type was restricted to journal articles. Table 1 provides an overview of the keywords used for the search and the corresponding number of articles retrieved.

Table 1. Searching keywords and articles found

No.	Keywords	N
1	mobile-assisted language learning AND theory	66
2	autonomous language learning OR language learner autonomy AND theory	11

Study Selection

The study inclusion and exclusion criteria are set as stated in Table 2.

Table 2. Inclusion and exclusion criteria

No.	Inclusion criteria	Exclusion criteria
1	Articles that are Empirical research	Articles that are not empirical research
2	Articles that are based on one or more learning theory	Articles that are not based on learning theory
3	Articles that are based on a learning theory suitable for designing listening activities	Articles that are based on a learning theory unsuitable for designing listening activities
4	Articles that are accessible	Articles that are not accessible

Based on the inclusion and exclusion criteria, 35 articles were excluded from the initial pool of 66 articles in MALL research. The reasons for exclusion are as follows:

1) 8 articles were not empirical research, such as literature reviews and commentaries.
2) 10 articles did not utilise a learning theory.
3) 15 articles were based on learning theories unsuitable for designing listening activities, including the Unified Theory of Acceptance and Use of Technology,

the Technology Acceptance Model, the Function Theory of Lexicography, and the Theory of Negotiation of Meaning.
4) 2 articles were inaccessible or unavailable.

As for ALL research, 6 articles were excluded from the initial pool of 11 articles. The reasons for exclusion are as follows:
1) 4 articles were not empirical research, such as literature reviews and commentaries.
2) 2 articles did not utilise a learning theory.

Data Extraction and Synthesis

A total of 31 articles in MALL research and 5 articles in ALL research were extracted and analysed. The thematic synthesis method, as outlined by Thomas and Harden (2008), was employed to extract the intended information from each article. This method consisted of three phases: line-by-line coding, development of descriptive themes, and generation of analytical themes.

In the first phase, line-by-line coding, each article was thoroughly reviewed to identify the theories underpinning the research. In the second phase, development of descriptive themes, the identified theories were organised into themes and presented in tables. The results for MALL research are reported in Table 3, while those for ALL research are presented in Table 5.

In the final phase, generation of analytical themes, the frequency of each theory appearing in the articles was calculated and ranked. The theories were then categorised into four overarching analytical themes based on common learning theories: behaviourism, cognitivism, constructivism, and connectivism. The results for MALL research are reported in Table 4, and those for ALL research are presented in Table 6.

This systematic approach ensured a structured and comprehensive extraction and synthesis of data, providing valuable insights into the theoretical foundations of MALL and ALL research.

RESULTS

The results are presented in 4 parts. First, theories used in MALL and ALL research are shown. Then suitable theories for MALL in autonomous listening are discussed. Finally, the MALL framework for autonomous listening is formulated.

Theories used in MALL research

Based on the 31 articles of MALL, Table 3 reports the theories used in each article.

Table 3. Reviewed articles in MALL

No.	Authors (Year)	Theory
1	Dai & Wu (2024)	Cognitive Load Theory
2	Zhu et al. (2024)	Skill Acquisition Theory
3	Zeng & Fisher (2024)	Self-Determination Theory
4	Pan et al. (2024)	Expectation Confirmation Theory
5	Wu et al. (2023)	The Theory of Associative Fluency
6	Guo et al. 2023）	The Theory of Epistemology
7	Alamer & Al Khateeb (2023)	Self-Determination Theory
8	Al-Abidi et al. (2023)	Self-Determination Theory
9	Alamer et al. (2023)	Self-Determination Theory
10	Li & Liontas (2023)	Sociocultural Theory
11	Xueting Ye & Shi (2023)	Situated Learning Theory
12	Kessler (2023)	Metacognition Theory
13	Hoi at al. (2023)	Self-Determination Theory
14	Lee & Xiong (2023)	Social Support Theory; Stimulus-Organism-Response Theory
15	Faozi & Handayani (2023)	Self-Determination Theory
16	Byrne (2023)	Activity Theory
17	Hu, et al. (2023)	Flow theory
18	Annamalai et al. (2022)	Self-Determination Theory
19	Mroz & Thrasher (2022)	Complex Dynamic Systems Theory
20	Chen & Zhao (2022)	Self-Determination Theory
21	Hsu & Lin (2022)	Action Control Theory
22	Luo (2022)	Micro-Learning Theory
23	Jeon (2022)	Self-Determination Theory
24	Hsu & Lin (2021)	Action Control Theory
25	Wrigglesworth (2020)	Sociocultural Theory
26	Jiang & Zhang (2020)	Social Presence Theory
27	Wang & Christiansen (2019)	Self-Determination Theory
28	Hwang et al. (2019)	Cognitive Load Theory
29	Lilley & Hardman (2017)	Cultural-Historical Activity Theory
30	Barcomb et al. (2017)	Activity Theory
31	Wang & Suwanthep (2017)	Constructivism

Next, the frequency of theories used in MALL research and their common learning theories are listed in Table 4.

Table 4. Theories used in MALL research

No.	Theories	Frequency	Common Learning Theories
1	Self-Determination Theory	10	Cognitivism
2	Cognitive Load Theory	2	Cognitivism
3	Action Control Theory	2	Cognitivism
4	Activity Theory	2	Constructivism
5	Sociocultural Theory	2	Constructivism
6	Expectation Confirmation Theory	1	Cognitivism
7	Skill Acquisition Theory	1	Cognitivism
8	Cultural-Historical Activity Theory	1	Constructivism
9	Theory of Associative Fluency	1	Cognitivism
10	Theory of Epistemology	1	Constructivism
11	Social Presence Theory	1	Connectivism
12	Flow Theory	1	Cognitivism
13	Situated Learning Theory	1	Constructivism
14	Metacognition Theory	1	Cognitivism
15	Social Support Theory	1	Connectivism
16	Stimulus-Organism-Response Theory	1	Cognitivism
17	Complex Dynamic Systems Theory	1	Connectivism
18	Micro-Learning Theory	1	Constructivism
19	Constructivism	1	Constructivism

Overall, 19 theories were identified across the 31 MALL research articles, with one article utilising two theories. The Self-Determination Theory emerged as the most frequently used theory. Cognitive Load Theory, Action Control Theory, Activity Theory, and Sociocultural Theory were each used twice, while the remaining theories were used only once. These theories are distributed across three learning paradigms: cognitivism, constructivism, and connectivism.

Theories used in ALL research

Table 5 reports the theories used in 5 articles in ALL.

Table 5. Reviewed articles in ALL

No.	Authors (Year)	Theory
1.	Selvaraj et al. (2024)	Transactional Distance Theory
2	Zare & Aqajani Delavar (2022)	Self-Determination Theory
3	Shelton-Strong (2022)	Self-Determination Theory
4	Tiansoodeenon & Sitthitikul (2022)	Multiple Intelligence Theory
5	Hawkins (2017)	Self-Determination Theory

Next, the frequency of theories used in ALL research and their common learning theories are listed in Table 6.

Table 6. Theories used in ALL research

Theories	Frequency	Common Learning Theories
Self-Determination Theory	3	Constructivism
Transactional Distance Theory	1	Constructivism
Multiple Intelligence Theory	1	Cognitivism

Overall, three theories were identified across the five ALL research articles: Self-Determination Theory, Transactional Distance Theory, and Multiple Intelligence Theory, with Self-Determination Theory being the most frequently used. Both Self-Determination Theory and Transactional Distance Theory are categorised under constructivism, while Multiple Intelligence Theory is classified under cognitivism.

Theories for MALL in autonomous listening

According to Table 4, among the 19 theories used in MALL research and the 3 theories used in ALL research, Self-Determination Theory (SDT) appeared most frequently. SDT, a motivational theory of personality, development, and social processes, posits that satisfying three basic psychological needs – autonomy, competence, and relatedness – enhances individual functioning and well-being (Deci & Ryan, 2015). SDT is closely tied to learner autonomy and is widely applied in both MALL and ALL research. These three basic needs align with Benson’s definition of learner autonomy, where Benson’s notions of capacity and freedom reflect competence and autonomy in

SDT (Hu & Zhang, 2017). SDT serves as a guiding framework for investigating students' needs for autonomy, competence, and relatedness within mobile applications (Jeno et al., 2022). Consequently, SDT was chosen as one of the theoretical bases for the MALL framework.

However, since SDT belongs to cognitivism and primarily focuses on learners' psychological aspects, an additional theory is required to complement SDT and inform the design of mobile-assisted autonomous listening activities. In Table 4, aside from the 8 theories classified under cognitivism, 11 other theories remain. Among these, Situated Learning Theory (SLT) is deemed the most suitable for designing mobile-assisted autonomous listening activities. According to a systematic review of theoretical frameworks in mobile learning (Chuah & Kabilan, 2022), principles such as Situated Learning and Collaborative Learning are highly engaging and beneficial for enhancing mobile language learning experiences. Since the framework focuses on listening, with limited collaboration between learners, Situated Learning is regarded as a key component.

The central concept of SLT is legitimate peripheral participation, which suggests that learners join communities of practitioners and that newcomers must fully engage in the socio-cultural practices of the community to acquire knowledge and skills (Lave & Wenger, 1991). Mahmoud M. S. Abdallah (2015) introduced the concept of "situated language learning" based on SLT, proposing various forms of situated learning, including communities of practice and authentic language learning.

Overall, SLT and SDT are identified as the most suitable theories for MALL in autonomous listening among the 19 theories reviewed.

The MALL Framework for Autonomous Listening

Based on Self-Determination Theory (SDT) and Situated Learning Theory (SLT), a comprehensive framework for mobile-assisted autonomous listening was formulated. This framework integrates the principles of autonomy, competence, and relatedness from SDT with SLT's emphasis on real-world context, authentic activities, social interactions, and the use of tools (see Figure 1).

Self-determination Theory

Autonomy refers to the sense of initiative and ownership in one's actions, which is fostered by experiencing interest and value and undermined by external manipulation, such as rewards or punishments (Ryan & Deci, 2020). Strategies to promote autonomy include providing choices and rationales for learning activities, understanding students' feelings about learning topics, and minimizing pressure and control (Niemiec & Ryan, 2009). In mobile-assisted autonomous listening, learners will have the freedom to select listening materials and activities that interest and suit them. They will also define their learning objectives, monitor their progress, and evaluate their outcomes independently.

Competence is the feeling of mastery, best supported in structured learning environments that provide optimal challenges, positive feedback, and growth opportunities (Ryan & Deci, 2020). It can be enhanced through effectance-relevant feedback and by offering tasks that are neither too easy nor too difficult (Niemiec & Ryan, 2009). In mobile-assisted autonomous listening, learners can adjust their listening time and pace, benefiting from support provided by mobile learning apps, peers, and teachers. These features help students feel effective, supported, and competent in their learning journey.

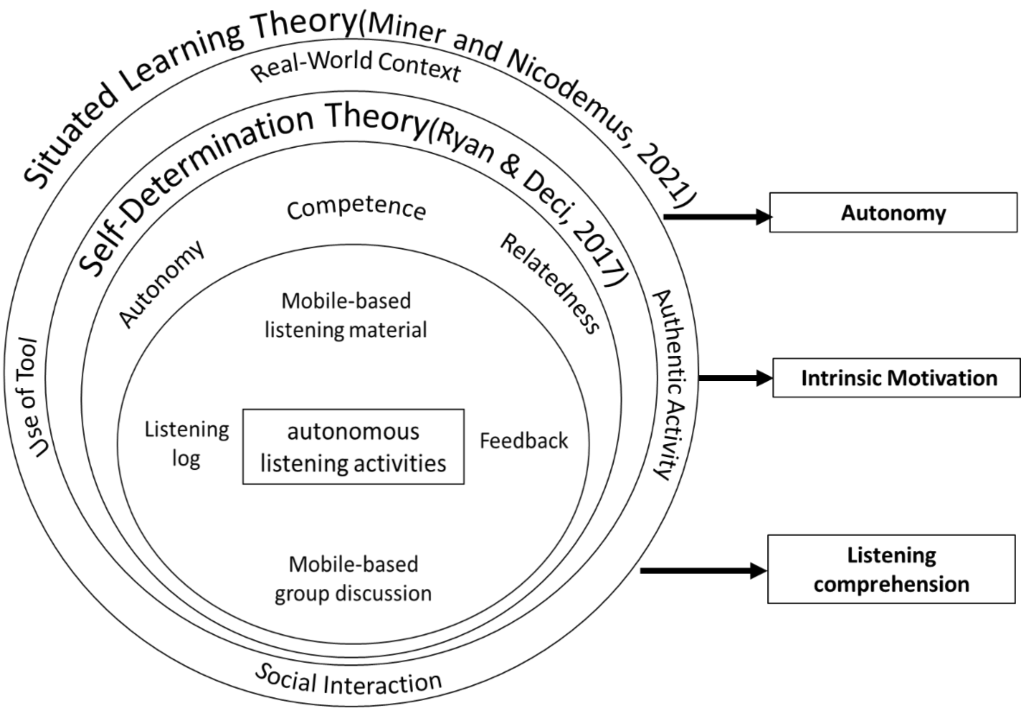

Figure 1. MALL framework for autonomous listening

Relatedness refers to the sense of belonging and connection, which is nurtured through respect and care (Ryan & Deci, 2020). In classrooms, relatedness is associated with students feeling that teachers genuinely like, respect, and value them (Niemiec & Ryan, 2009). In mobile-assisted autonomous listening, learners will engage in online learning communities with peers and teachers, sharing their learning experiences. This interaction fosters a sense of connection and involvement, enhancing their learning experience.

Situated Learning Theory

SLT emphasizes legitimate peripheral participation, where learners join communities of practitioners and engage in the socio-cultural practices of the community to acquire knowledge and skills (Lave & Wenger, 1991). SLT is widely applied in language education and interpreted through various lenses. For this framework, Annette Miner and Brenda Nicodemus' model of SLT, which includes real-world context, authentic activities, social interactions, and the use of tools (Miner & Nicodemus, 2021), was adopted.

The real-world context component of SLT emphasizes integrating authentic, everyday materials into the learning experience, bridging the gap between classroom learning and practical language use (Hwang et al., 2016). A situated real-world context helps students practice more frequently and produce meaningful, accurate sentences, enhancing their understanding of the language's cultural and situational aspects. In mobile-assisted autonomous listening, learners will engage with authentic materials, such as BBC news, to create a meaningful and immersive experience.

Authentic activities allow learners to use the target language in genuine contexts for real-world purposes (Ozvirer & Herrington, 2011). These activities promote organic and meaningful language exploration, enhancing learners' interest and practical skills. In mobile-assisted autonomous listening, students will participate in tasks such as maintaining a listening log, which mimics real-world applications.

The social interaction component underscores the importance of a dynamic and collaborative learning environment. Social interaction is crucial for language acquisition as it fosters collaboration and dynamic learning (Lytle & Kuhl, 2017). In mobile-assisted autonomous listening, learners will exchange ideas, share perspectives, and receive constructive feedback from peers and instructors, creating a collaborative and interactive learning environment.

Leveraging mobile technology is a key aspect of SLT. Technology provides learners with convenient access to authentic materials and resources, enabling them to engage with listening activities and communicate with peers and teachers (Hwang et al., 2016). In mobile-assisted autonomous listening, learners will use mobile apps to access listening materials, complete activities, and interact with their learning community via social media.

The goal of this framework is to address both learners' psychological needs and the design of the learning environment. First, SLT is employed to establish the learning environment, emphasizing real-world context, authentic activities, social interaction, and tools. Then, SDT is applied to satisfy learners' psychological needs for autonomy, competence, and relatedness within this environment.

Based on these two theories, mobile-assisted autonomous listening activities are designed to provide a holistic and effective language learning experience.

DISCUSSION

Among 31 research on Mobile-Assisted Language Learning (MALL), 19 different learning theories were identified, spanning cognitivism, constructivism, and connectivism. The most prevalent theory was Self-Determination Theory (SDT), which was used in nine articles. Other theories, such as Cognitive Load Theory, Action Control Theory, Activity Theory, and Sociocultural Theory, were each used twice. Overall, cognitivism emerged as the most common theoretical foundation in MALL research from 2014 to 2024, reflecting an increasing focus on learners' psychological aspects. In contrast, connectivism was the least utilized theoretical base, aligning with prior findings that MALL research often lacks emphasis on human interaction. This highlights the need for further exploration of MALL through the lens of connectivism.

In the context of Autonomous Language Learning (ALL), only 11 articles were found in SCOPUS from 2014 to 2024, indicating a significant gap in research in this area. Similar to MALL, SDT was the most frequently used theory in ALL research, underscoring its close connection to language learner autonomy. The other theories identified in ALL research also relate to fostering autonomy, each addressing this goal through diverse approaches.

The proposed MALL framework for autonomous listening integrates key components from both SDT and Situated Learning Theory (SLT). This framework combines the principles of autonomy, competence, and relatedness from SDT with SLT's focus on real-world context, authentic activity, social interactions, and the use of tools. The aim is to create a comprehensive framework that addresses learners' psychological needs while also designing an effective learning environment.

According to SDT, the framework prioritizes students' basic psychological needs. Autonomy is supported by enabling students to engage in listening activities outside the classroom without teacher intervention. Competence is facilitated through app features that allow learners to adjust playback speed, pause, access transcripts, and receive teacher feedback. Relatedness is fostered by enabling interaction with teachers and peers through group chats on platforms like WhatsApp, both before and after listening activities. By meeting these needs, intrinsic motivation and the internalization of external motivation can be enhanced, leading to improved academic achievement (Ryan & Deci, 2020).

The framework also incorporates Miner and Nicodemus's SLT model, which aligns well with the principles of language learning. To complement SDT, SLT provides a suitable learning environment by emphasizing real-world context, authentic activities, social interaction, and the use of tools. Real-world context is addressed by allowing students to choose when and where to listen, using authentic materials such as podcasts, news, and stories available through the app. Authentic activity is incorporated by requiring students to grasp the general meaning of the material and maintain a listening log, rather than merely completing follow-up questions. Social interaction is supported by involving students in online learning communities where they can exchange feedback with peers and teachers. The use of tools is optimized through mobile apps, which provide easy access to authentic materials and facilitate online communication.

The uniqueness of this framework lies in its integration of SDT and SLT components to support MALL in autonomous listening. This integration also enables an analysis of its effects on learners' autonomy, motivation, and listening comprehension. The framework leverages insights from prior MALL and ALL research to design activities that enhance autonomy, intrinsic motivation, and listening comprehension.

CONCLUSION

A critical analysis of 31 MALL articles and 11 ALL articles revealed prevalent theories used in these fields. SDT emerged as the most commonly used theory in both MALL and ALL research, reflecting an increasing interest in learners' psychological needs. However, the lack of connectivist theories highlights the need for more research focused on human interaction within MALL.

From the 21 identified theories, SDT and SLT were chosen as the theoretical foundations for the proposed MALL framework for autonomous listening. SLT was utilized to design a situated mobile learning environment, while SDT was employed to promote learner autonomy and motivation. The framework integrates key principles of autonomy, competence, and relatedness from SDT with SLT's emphasis on real-world context, authentic activities, social interaction, and tools.

The resulting autonomous listening activities include mobile-based listening materials, listening logs, mobile-based group discussions, and feedback. These activities are designed to enhance learners' autonomy, increase intrinsic motivation, and improve listening comprehension. This framework provides valuable guidance for instructors, learners, and app developers engaged in mobile-assisted listening activities.

Instructors can use the framework to design materials and activities that support learner autonomy. Learners can leverage the framework to create their own listening activities, gaining greater exposure and learning opportunities. App developers can use the framework as a guideline for designing listening apps that facilitate learner autonomy.

Beyond providing a framework for practice, this study highlights the importance of theory in shaping how we understand and evaluate mobile learning tools. The findings suggest that educators, researchers, and developers need to be mindful of the theoretical assumptions they bring to the table. Tools may appear to be theory-neutral, but their use and interpretation are heavily influenced by the pedagogical frameworks applied. Future research could explore how divergent theoretical stances lead to different learning outcomes even when the same technology is used. This perspective invites more nuanced and reflective applications of mobile technologies in language education.

LIMITATIONS AND FUTURE STUDIES

While the proposed framework offers valuable guidance for mobile-assisted autonomous listening, it has certain limitations. The framework primarily focuses on listening skills and applying it to other language skills – such as reading, writing, and speaking – requires further investigation and adaptation. Although the theoretical foundations of SDT and SLT are applicable to all language skills, the specific design of learning activities would need to be tailored to each skill. Another limitation is that the framework is based solely on a critical review of existing literature and lacks empirical validation. Future studies should conduct empirical research to evaluate the framework's effectiveness in enhancing learner autonomy, motivation, and listening comprehension.

Further research could also explore the integration of connectivist principles into MALL to address the lack of human interaction in current frameworks. Investigating the framework's application across diverse contexts and learner groups would provide additional insights and refinements.

REFERENCES

Abdallah, M. M. S. (2015, May 20). *Situated language learning: Concept, significance and forms* [Worksheet presented at the College of Education Young Researchers' Conference]. Assiut University, Egypt. Available from https://www.researchgate.net/publication/277404276

Al-Abidi, S., Owais, A., & Alabedi, F. (2023). The Effects of Using MS Teams Mobile Application on Language Learners' Motivation During and After the Covid-19

Pandemic. *World Journal of English Language*, *13*(2), Article 2. https://doi.org/10.5430/wjel.v13n2p260

Alamer, A., & Al Khateeb, A. (2023). Effects of using the WhatsApp application on language learners motivation: A controlled investigation using structural equation modelling. *Computer Assisted Language Learning*, *36*(1–2), 149–175. https://doi.org/10.1080/09588221.2021.1903042

Alamer, A., Al Khateeb, A., & Jeno, L. M. (2023). Using WhatsApp increases language students' self-motivation and achievement, and decreases learning anxiety: A self-determination theory approach. *Journal of Computer Assisted Learning*, *39*(2), 417–431. https://doi.org/10.1111/jcal.12753

Annamalai, N., Kabilan, M., & Soundrarajan, D. (2022). Smartphone apps as a motivating tool in English language learning. *Indonesian Journal of Applied Linguistics*, *12*, 201–211. https://doi.org/10.17509/ijal.v12i1.46544

Barcomb, M., Grimshaw, J., & Cardoso, W. (2017). I Can't Program! Customizable Mobile Language-Learning Resources for Researchers and Practitioners. *Languages*, *2*(3), Article 3. https://doi.org/10.3390/languages2030008

Benlaghrissi, H., & Ouahidi, L. M. (2024). The impact of mobile-assisted project-based learning on developing EFL students' speaking skills. *Smart Learning Environments*, *11*(1). https://doi.org/10.1186/s40561-024-00303-y

Benson, P. (2011). *Teaching and researching: Autonomy in language learning* (2nd ed.). Routledge. https://doi.org/10.4324/9781315833767

Bozorgian, H., & Shamsi, E. (2022). Autonomous use of podcasts with metacognitive intervention: Foreign language listening development. *International Journal of Applied Linguistics*, *32*(3), 442–458. https://doi.org/10.1111/ijal.12439

Bozorgian, H., Muhammadpour, M., & Qara, R. (2024). EFL Listening Log: A Conceptual Replication of Kemp's (2010) Study on Motivating Autonomous Learning. *Iranian Journal of Language Teaching Research*, *12*(1), 65–82. https://doi.org/10.30466/ijltr.2024.121418

Byrne, J. (2023). A Determinant of Optimal and Inhibited Mobile Language Learning Activity Quiz Level Length. *International Journal of Interactive Mobile Technologies (iJIM)*, *17*, 47–68. https://doi.org/10.3991/ijim.v17i10.38417

Chen, Y., & Zhao, S. (2022). Understanding Chinese EFL Learners' Acceptance of Gamified Vocabulary Learning Apps: An Integration of Self-Determination Theory and Technology Acceptance Model. *Sustainability*, *14*, 11288. https://doi.org/10.3390/su141811288

Chuah, K.-M., & Kabilan, M. K. (2022). The Development of Mobile Applications for Language Learning: A Systematic Review of Theoretical Frameworks. *International Journal of Learning, Teaching and Educational Research*, *21*(8), 253–270. https://doi.org/10.26803/ijlter.21.8.15

Dai, Y., & Wu, Z. (n.d.). Learning (semi-)technical music words with mobile dictionary and/or machine-translation apps: Performances and perceptions. *Computer Assisted Language Learning*, 1–22. https://doi.org/10.1080/09588221.2024.2412788

Deci, E. L., & Ryan, R. M. (2015). Self-Determination Theory. In J. D. Wright (Ed.), *International Encyclopedia of the Social & Behavioral Sciences* [2nd ed.] (pp. 486–491). Elsevier. https://doi.org/10.1016/B978-0-08-097086-8.26036-4

Diari, K. P. Y., Suwarna, S., & Suweta, I. M. (2023). Mobile Technology-Mediated Language Learning: A Quantitative Study to Unravel Language Learners' Achievement and Autonomy. *World Journal of English Language*, *13*(5), 354–364. https://doi.org/10.5430/wjel.v13n5p354

Ebrahimi, S. S. (2024). Effects of mobile messaging applications on writing skill. *Ampersand*, *13*. https://doi.org/10.1016/j.amper.2024.100209

Faozi, F. H., & Handayani, P. W. (2023). The Antecedents of Mobile-Assisted Language Learning Applications Continuance Intention. *Electronic Journal of E-Learning*, *21*(4), 299–313. https://doi.org/10.34190/ejel.21.4.2744

Fatimah, A., Santiana, S., & Sulastri, F. (2021). Learner's experience on the use of mobile devices for autonomous listening: A narrative inquiry. *Journal of Language and Linguistic Studies*, *17*(1), 193–204. https://doi.org/10.17263/jlls.903375

Green, C., Eady, M., & Andersen, P. (2018). Preparing quality teachers: Bridging the gap between tertiary experiences and classroom realities. *Teaching and Learning Inquiry*, *6*(1), Article 1. https://doi.org/10.20343/teachlearninqu.6.1.10

Grosjean, F., Byers-Heinlein, K., Antoniou, M., Grüter, T., Hartsuiker, R. J., Peña, E. D., Bedore, L. M., & Shi, L.-F. (2018). *The listening bilingual: Speech perception, comprehension, and bilingualism*. Wiley Blackwell. https://doi.org/10.1002/9781118835722

Guo, B., Wang, Y., & Yin, J. (2023). A multi-perspective reflection on college students' English vocabulary and language skills learning under the theory of epistemology. *European Journal for Philosophy of Religion*, *15*(4), Article 4. https://doi.org/10.24204/ejpr.2023.4000

Hawkins, S. (2017). Cooperative learning's role in in enhancing motivation through autonomy: Possibilities and limitations within a Japanese context. *Asian EFL Journal*, *19*, 62–77.

He, X. (Stella), & Loewen, S. (2022). Stimulating learner engagement in app-based L2 vocabulary self-study: Goals and feedback for effective L2 pedagogy. *System*, *105*, 102719. https://doi.org/10.1016/j.system.2021.102719

Hoi, L. M., Sun, Y., Ke, W., & Im, S. K. (2023). Visualizing the behavior of learning European Portuguese in different regions of the world through a mobile application. *IEEE Access*, *11*, 113913–113930. https://doi.org/10.1109/ACCESS.2023.3324390

Hsu, H.-T., & Lin, C. (2021). Extending the technology acceptance model of college learners' mobile-assisted language learning by incorporating psychological constructs. *British Journal of Educational Technology*, *53*. https://doi.org/10.1111/bjet.13165

Hsu, H. T., & Lin, C. C. (2022). Factors Influencing University Students' Intention to Engage in Mobile-assisted Language Learning through the Lens of Action Control Theory. *Educational Technology and Society*, *25*(4), 29–42.

Hu, L., Hei, D., Wang, H., & Dai, X. (2023). Chinese college students collaborative mobile-assisted language learning experience and flow as a key factor for further adoption. *Frontiers in Psychology*, *14*. https://doi.org/10.3389/fpsyg.2023.1165332

Hu, P., & Zhang, J. (2017). A pathway to learner autonomy: a self-determination theory perspective. *Asia Pacific Education Review*, *18*(1), 147–157. https://doi.org/10.1007/s12564-016-9468-z

Hwang, G.-J., Hsu, T.-C., & Hsieh, Y.-H. (2019). Impacts of different smartphone caption/subtitle mechanisms on English listening performance and perceptions of students with different learning styles. *International Journal of Human-Computer Interaction*, *35*(4–5), 333–344. https://doi.org/10.1080/10447318.2018.1543091

Hwang, W.-Y., Shih, T. K., Ma, Z.-H., Shadiev, R., & Chen, S.-Y. (2016). Evaluating listening and speaking skills in a mobile game-based learning environment with situational contexts. *Computer Assisted Language Learning*, *29*(4), Article 4. https://doi.org/10.1080/09588221.2015.1016438

Janfeshan, K., Sharhan, A. N., & Janfeshan, M. M. (2023). Effects of Using the WhatsApp Application on Iranian Intermediate EFL Learners' Vocabulary Learning and Autonomy. *The International Review of Research in Open and Distributed Learning*, *24*(3), 145–163. https://doi.org/10.19173/irrodl.v24i3.7185

Jeno, L. M., Egelandsdal, K., & Grytnes, J.-A. (2022). A qualitative investigation of psychological need-satisfying experiences of a mobile learning application: A Self-Determination Theory approach. *Computers and Education Open*, *3*, 100108. https://doi.org/10.1016/j.caeo.2022.100108

Jeon, J. (2022). Exploring a self-directed interactive app for informal EFL learning: A self-determination theory perspective. *Education and Information Technologies*, *27*(4), 5767–5787. https://doi.org/10.1007/s10639-021-10839-y

Jiang, D., & Zhang, L. J. (2020). Collaborating with 'familiar' strangers in mobile-assisted environments: The effect of socializing activities on learning EFL writing. *Computers & Education*, *150*, 103841. https://doi.org/10.1016/j.compedu.2020.103841

Kamasak, R., Özbilgin, M., Atay, D., & Kar, A. (2021). The Effectiveness of Mobile-Assisted Language Learning (MALL). In *IGI Global eBooks* (pp. 194–212). https://doi.org/10.4018/978-1-7998-4769-4.ch008

Kessler, M. (2023). Supplementing mobile-assisted language learning with reflective journal writing: A case study of Duolingo users' metacognitive awareness. *Computer Assisted Language Learning*, *36*(5–6), 1040–1063. https://doi.org/10.1080/09588221.2021.1968914

Kessler, M., Loewen, S., & Gönülal, T. (2023). Mobile-assisted language learning with Babbel and Duolingo: Comparing L2 learning gains and user experience. *Computer Assisted Language Learning*. *38*(4), 690-714 https://doi.org/10.1080/09588221.2023.2215294

Kitchenham, B. (2004). *Procedures for performing systematic reviews* (Joint Technical Report TR/SE-0401). Keele University, Department of Computer Science, & National ICT Australia Ltd.

Koleini, N., Boroughani, T., Eslami, Z. R., & Xodabande, I. (2024). Exploring the impacts of mobile-assisted learning on university students' technical vocabulary knowledge. *International Journal of Educational Research Open*, *7*. https://doi.org/10.1016/j.ijedro.2024.100344

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press. https://doi.org/10.1017/CBO9780511815355

Lee, J.-C., & Xiong, L. (2023). Exploring learners' continuous usage decisions regarding mobile-assisted language learning applications: A social support theory perspective. *Education and Information Technologies*, *28*(12), 16743–16769. https://doi.org/10.1007/s10639-023-11884-5

Li, Z., & Liontas, J. (2023). English VP Idiom Learning and WeChat: Developing Idiomatic Competence among Chinese EFL Learners. *Iranian Journal of Language Teaching Research, 11*(2). https://doi.org/10.30466/ijltr.2023.121332

Lilley, W., & Hardman, J. (2017). "You focus, I'm talking": A CHAT analysis of mobile dictionary use in an advanced EFL class. *Africa Education Review*, *14*, 1–19. https://doi.org/10.1080/18146627.2016.1224592

Little, D. (2022). Language learner autonomy: Rethinking language teaching. *Language Teaching*, *55*(1), 64–73. https://doi.org/10.1017/S0261444820000488

Luo, L. (2022). Novel micro-learning-based mobile-assisted language app for Mandarin Chinese. *Journal of Applied Learning and Teaching*, *5*(Sp. Iss. 1), Article Sp. Iss. 1. https://doi.org/10.37074/jalt.2022.5.s1.5

Lytle, S. R., & Kuhl, P. K. (2017). Social Interaction and Language Acquisition. In *The Handbook of Psycholinguistics* (pp. 615–634). John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118829516.ch27

Meletiadou, E. (2023). Experimenting With AI-Powered Learning Tools and Mobile-Assisted Learning to Improve Student Learning Performance, Autonomy, and Metacognitive Skills: A Case Study of Quizlet. In E. Meletiadou (Ed.), *Handbook of Research on Redesigning Teaching, Learning, and Assessment in the Digital Era* (pp. 21-41). IGI Global Scientific Publishing. https://doi.org/10.4018/978-1-6684-8292-6.ch002

Miner, A., & Nicodemus, B. (2021). *Situated learning in interpreter education: From the classroom to the community*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-68904-9

Mroz, A. P., & Thrasher, T. (2022). Proficiency development and smartphone usage in study abroad: Microgenetic longitudinal case studies of French learners. *Foreign Language Annals*, *55*(2), 455–493. https://doi.org/10.1111/flan.12619

Niemiec, C., & Ryan, R. (2009). Autonomy, competence, and relatedness in the classroom: Applying self-determination theory to educational practice. *Theory and Research in Education*, *7*, 133–144. https://doi.org/10.1177/1477878509104318

Okai-Ugbaje, S., Ardzejewska, K., & Imran, A. (2022). A mobile learning framework for higher education in resource constrained environments. *Education and Information Technologies*, *27*, 1–23. https://doi.org/10.1007/s10639-022-11094-5

Palfreyman, D. M., & Benson, P. (2019). Autonomy and Its Role in English Language Learning: Practice and Research. In X. Gao (Ed.), *Second Handbook of English*

Language Teaching (pp. 661–681). Springer International Publishing. https://doi.org/10.1007/978-3-030-02899-2_38

Pan, L., Ye, Y., & Li, X. (2024). Factors affecting Thai EFL students' behavioral intentions toward mobile-assisted language learning. *Frontiers in Education*, *9*. https://doi.org/10.3389/feduc.2024.1333771

Peng, C., Rashid, S. Md., & Jiang, L. (2024). The use of metacognitive strategies within a mobile-assisted language learning context: Enhancing Chinese EFL learner's listening skills. *Forum for Linguistic Studies*, *6*(6), 410–428. https://doi.org/10.30564/fls.v6i6.7439

Pham, L. L. N., Nguyen, H. T., & Le, V. T. K. (2021). Triggering Students' Learning Autonomy Using the Combination of M-Learning and Gamification: A Case Study at Nguyen Tat Thanh University. *Teaching English with Technology*, *21*(2), 66–91.

Pyo, J., & Lee, C. H. (2022). Academic engagement and task completion in L2 listening through mobile-assisted blended learning (MABL) in higher education. *Korean Journal of English Language and Linguistics*, *22*, 1389–1416. https://doi.org/10.15738/kjell.22..202212.1389

Rashid, S., & Howard, J. (2023). Blogging with smartphones for independent writing practice beyond the EFL classroom. *Indonesian Journal of Applied Linguistics*, *12*(3), 790–801. https://doi.org/10.17509/ijal.v12i3.46086

Read, T., & Bárcena, E. (2020). Hacia un marco para los MOOC de idiomas y el aprendizaje de idiomas con asistencia móvil [Towards a framework for language MOOCs and mobile-assisted language learning]. *Propósitos y Representaciones*, *8*(1). https://doi.org/10.20511/pyr2020.v8n1.470

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemporary Educational Psychology*, *61*, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Sato, T., Murase, F., & Burden, T. (2020). An empirical study on vocabulary recall and learner autonomy through mobile-assisted language learning in blended learning settings. *CALICO Journal*, *37*(3), 254–276. https://doi.org/10.1558/cj.40436

Selvaraj, V., Shah, A. H., S, D. H. P. K., Subasini, N. S., & Ameen, D. A. S. (2024). Autonomous language learning in CALL environments using transactional distance theory. *Computer-Assisted Language Learning Electronic Journal*, *25*(1), 148–167. https://callej.org/index.php/journal/article/view/99/369

Shelton-Strong, S. J. (2022). Advising in language learning and the support of learners' basic psychological needs: A self-determination theory perspective. *Language Teaching Research*, *26*(5), 963–985. https://doi.org/10.1177/1362168820912355

Shen, B., Bai, B., & Xue, W. (2020). The effects of peer assessment on learner autonomy: An empirical study in a Chinese college English writing class. *Studies in Educational Evaluation*, *64*, 100821. https://doi.org/10.1016/j.stueduc.2019.100821

Solmaz, O. (2024). Impacts of digital applications on emergent multilinguals' language learning experiences: The case of Duolingo. *Education and Information Technologies*. https://doi.org/10.1007/s10639-024-13185-x

Stockwell, G., & Wang, Y. (2024). Expanding the learning ecology and autonomy of language learners with mobile technologies. *Educational Technology and Society*, *27*(2), 60–69. https://doi.org/10.30191/ETS.202404_27(2).SP05

Thi Mai, V. L. (2023). Autonomy-Based Listening: Vietnamese University Students' Perceptions of Self-Access Web-Based Listening Practices. *SiSal Journal*, *14*(3), 267–286. https://doi.org/10.37237/140303

Thomas, J., & Harden, A. (2008). Methods for the thematic synthesis of qualitative research in systematic reviews. *BMC Medical Research Methodology*, *8*, 45. https://doi.org/10.1186/1471-2288-8-45

Tiansoodeenon, M., & Sitthitikul, P. (2022). Effects of Multiple Intelligences-based Instruction on English Achievement and Learner Autonomy of Thai Tertiary Students. *The Journal of AsiaTEFL*, *19*(4), 1250–1266. https://doi.org/10.18823/asiatefl.2022.19.4.7.1250

Viberg, O., Wasson, B., & Kukulska-Hulme, A. (2020). Mobile-assisted language learning through learning analytics for self-regulated learning (MALLAS): A conceptual framework. *Australasian Journal of Educational Technology*, *36*(6), 34–52. https://doi.org/10.14742/ajet.6494

Wang, F., & Suwanthep, J. (2017). Constructivism-Based Mobile Application for EFL Vocabulary Learning. *International Journal of Learning and Teaching*. https://doi.org/10.18178/ijlt.3.2.106-112

Wang, X., Hamat, A. B., & Ng, L. S. (2024). Designing a pedagogical framework for mobile-assisted language learning. *Heliyon*, *10*(7), e28102. https://doi.org/10.1016/j.heliyon.2024.e28102

Wang, Y., & Christiansen, M. S. (2019). An Investigation of Chinese Older Adults' Self-Directed English Learning Experience Using Mobile Apps. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT)*, *9*(4), 51–71. https://doi.org/10.4018/IJCALLT.2019100104

Wrigglesworth, J. (2020). Using smartphones to extend interaction beyond the EFL classroom. *Computer Assisted Language Learning*, *33*(4), 413–434. https://doi.org/10.1080/09588221.2019.1569067

Wu, W.-C., Lin, I.-T., & Chen Hsieh, J. (2023). Ubiquitous English Idiom Learning Through Mobile Applications: Learning Outcomes, Motivation, Anxiety, and Behavioral Patterns. *The Asia-Pacific Education Researcher*, *32*(5), 665–684. https://doi.org/10.1007/s40299-022-00685-y

Xueting Ye, S., & Shi, J. (2023). Investigating the potential of changing the smartphone system language to L2 for facilitating vocabulary learning and motivation. *Language Teaching Research*, 13621688221145565. https://doi.org/10.1177/13621688221145565

Yang, F.-Y. (2021). EFL learners' autonomous listening practice outside of the class. *SiSal Journal*, *12*(4), 328–346. https://doi.org/10.37237/110403

Zare, J., & Aqajani Delavar, K. (2024). Enhancing English learning materials with data-driven learning: A mixed-methods study of task motivation. *Journal of Multilingual and Multicultural Development*, *45*(9), 4011–4027. https://doi.org/10.1080/01434632.2022.2134881

Zeng, C., & Fisher, L. (2024). Opening the "Black Box": How Out-of-Class Use of Duolingo Impacts Chinese Junior High School Students' Intrinsic Motivation for English. *ECNU Review of Education*, *7*(2), 283–307. https://doi.org/10.1177/20965311231171606

Zhu, J., Zhang, X., & Li, J. (2024). Using AR filters in L2 pronunciation training: Practice, perfection, and willingness to share. *Computer Assisted Language Learning*, *37*(5–6), 1364–1396. https://doi.org/10.1080/09588221.2022.2080716

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Research article

A Digital Technology for Learning English Terminology through Glossary Compilation

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Abstract
The article examines modern digital tools that enhance the effectiveness of professional foreign language acquisition by non-linguistic students. The resources presented here contribute to successful professional terminology acquisition by means of compiling specific scientific lexicons utilizing computer-aided vocabulary-building tools. The authors share the results of their practical work in Russia and present their considerations from the Russian experience regarding advantages and disadvantages of using the applications by modern students. The design encompasses a review of modern applications that can provide support in improving their vocabulary to both professional linguists and students of non-linguistic fields that help to master their language skills alongside with developing one's academic, communicative and intercultural competencies. The applications utilized in the study are TermoStat Web, AGROVOC, WIPO Pearl, and Notion. The article depicts strong and weak points of each tool and their benefits for students. Among the most important findings is the fact that the applications tested by the authors can be used at almost any language proficiency level. Practical implication embodies the possibility of embedding the findings in the current curricula of English for Specific Purposes taught in non-linguistic Universities. The results may have significant academic and social implications making students more thoughtful about the subjects they are not well versed in and more confident and well-prepared for work in multicultural environment. The singularity of the design lies in the fact that the tested computerized instruments are considered as one of the main teaching aids and can be recommended to be widely used in the modern foreign language teaching curricula.

Keywords: Terminology; Term; Term extraction; Text corpus; Terminological system; Special text; Foreign language learning

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Научная статья

Цифровая методика обучения англоязычной терминологии посредством составления глоссариев

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Аннотация

В статье рассмотрены современные цифровые инструменты, использование которых повышает эффективность обучения профессиональному иностранному языку студентов нелингвистических направлений подготовки. Исследованные информационные продукты способствуют успешному овладению профессиональной терминологией на иностранном языке путем составления глоссариев с использованием автоматизированных средств формирования словарного запаса. Авторы рассматривают преимущества и недостатки применения подобных приложений современными студентами, основываясь на результатах своей практической деятельности в России. В работе приведен обзор актуальных приложений (платформ), которые могут оказать помощь в расширении словарного запаса как профессиональным лингвистам, так и студентам неязыковых специальностей. Приведенный инструментарий помогает студентам овладеть языковыми навыками наряду с развитием академической, коммуникативной и межкультурной компетенций. Использованы такие приложения, как TermoStat Web, AGROVOC, WIPO Pearl и Notion. В статье описаны сильные и слабые стороны каждого инструмента и их преимущества для студентов. Одним из наиболее важных выводов является тот факт, что протестированные авторами приложения могут быть использованы практически на любом уровне владения языком. Практическая значимость заключается в возможности внедрения полученных результатов в текущие учебные программы по английскому языку для специальных целей в неязыковых вузах. Подобные средства обучения имеют ряд значительных академических и социальных преимуществ, помогая студентам более вдумчиво относиться к сложному предмету, улучшая его понимание и усвоение, а также стать более уверенными и хорошо подготовленными к работе в мультикультурной среде. Особенность разработки заключается в том, что протестированные компьютеризированные инструменты рассматриваются как одно из основных средств обучения и могут быть рекомендованы к широкому использованию в современных учебных программах по иностранным языкам.

Ключевые слова: Терминология; Термин; Извлечение терминов; Корпус текстов; Терминологическая система; Узкоспециальный текст; Обучение иностранному языку

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INTRODUCTION

The Council of Europe, UNESCO, the United Nations (UN) and the International Association of Universities (IAU) have long been committed to the internationalization of education and intercultural cooperation within academic communities. As part of the UN 2030 Agenda for Sustainable Development, one of the main objectives is to integrate global knowledge and best practices into university curricula. This is in line with efforts to prepare students for the global workforce by promoting intercultural competencies and advanced communication skills. Europe values multilingualism and the effective use of languages in professional contexts through the Common European Framework of Reference for Languages (CEFR). Likewise, the IAU actively supports initiatives to improve global academic collaboration, including exchange programs and joint research projects. In its most recent report on the internationalization of higher education (April 2024), the IAU emphasized the growing importance of virtual internationalization, for example through online exchanges and internships. These initiatives offer students the opportunity to connect with international peers and expand their academic horizons without the need for physical mobility. Over the past five years, virtual internationalization has increased significantly, highlighting the need for its inclusion in educational programs (Marinoni & Pina Cardona, 2024).

The emphasis on virtual internationalization underscores the importance of equipping Russian university students with the skills to navigate digital international networks and participate in global educational and research initiatives. This trend not only increases access to international resources, but also promotes global competencies that are critical for professional success in multicultural environments. These developments are in line with the Russian State Educational Standards for Higher Education, which highlight three key universal competencies for master's graduates: communication, intercultural interaction and self-organization with self-development. Communication competency focuses on the use of modern communication technologies, including foreign languages for academic and professional purposes. It enables students to read specialist literature, write texts and present research results at scientific events. Intercultural interaction develops the ability to communicate effectively across cultural boundaries, recognize diversity and promote teamwork in different socio-cultural contexts. The competency of self-organization and self-development emphasizes self-directed growth and equips students with skills for self-assessment, information analysis, and lifelong learning. In the master's program in Agronomy (field of study 35.04.04), these skills are implemented through the “Foreign Language” course which is focused on English for Specific Purposes. Through this course, students will learn how to use digital tools to solve academic and professional communication problems, access and evaluate global scholarly resources, and engage in professional discussions in English. It ensures that graduates are prepared for the demands of the globalized academic and professional environment. This paper presents the observation results recorded by the authors who teach students at Russian State Agrarian University-Moscow Timiryazev Agricultural Academy. The considerations from the Russian experience may be of interest both for Russian and international readership.

PROBLEM DEFINITION

Working with scientific articles from foreign sources often requires processing information in English. These articles contain technical terms related to their scope of scientific studies, which require appropriate understanding and translation from English into Russian. The topic has been reflected on by scientists for a long time (Lotte, 1982; Malyarchuk-Proshina & Burlachenko, 2020; Volgina, 2013). Artificial intelligence (AI) has added machine-driven inventory of new tools contributing to more effective and precise language learning in all research areas, especially when teaching Agronomy students (Vigna-Taglianti, 2024). On the one hand, this advancement enhances the efficiency of learning process, on the other hand, students often prefer to use built-in translators based on neural network technologies rather than traditional dictionaries and manual glossary creation. This often leads to significant distortions in the understanding of the terms and thereby reduces the quality of their scientific work (Jolley & Maimone, 2022; Kartasheva, 2024; Schmidt & Strasser, 2022).

Neural translators like ChatGPT achieve high efficiency when we add contextual information – such as the target audience, the purpose of the text, stylistic features and the subject area – such systems can take into account specific translation needs. This approach adapts register, style and translation approach depending on the task. Terminological accuracy increases when supplemented by bilingual terminological glossaries (Ryabchikova, 2024; Siu, 2023).

However, without appropriate preparation, automated translators often fail to convey the correct meaning of complex terms and fixed expressions typical of scientific texts. Modern machine translation systems often rely on word-for-word translation algorithms, which leads to misinterpretation of technical terms. For example, polysemic terms, neologisms, interdisciplinary terms or complex multi-component terminological expressions such as *data-driven sustainable agricultural practices* require detailed analysis and knowledge of the context in which they are used (Alipichev et al., 2023; Rothwell et al., 2023).

Sociocultural differences between countries can lead to discrepancies in agricultural terminology (Zaripova et al., 2024). Climate, geographic factors, and historical experiences influence regional agricultural practices and terminology. Country-specific agricultural policies and regulations often require adjustments to adapt to the legal context of the target language. Even universal terms like *soil health* can be interpreted differently depending on the region, reflecting different agricultural priorities and underlying cultural values. Soil health practices adapt to regional needs: *intensive agricultural areas* emphasize erosion control and nutrient optimization (e.g. no-till and cover cropping); *drylands* emphasize salinity management and drought resilience (e.g., mulching and biochar); and in the European Union (EU), sustainability efforts focus on biodiversity, organic matter and reduced use of chemicals, supporting organic farming and soil conservation. Translating *soil health* into Russian requires not only a literal translation, but also an adaptation to the scientific and practical realities of Russian farming methods (Weninger et al., 2024). Agricultural practices vary significantly with region, resulting in technical terms that may not have exact equivalents in other languages.

In addition to the asymmetry, translation difficulties also arise due to their multicomponent nature (Leitchik 2012; Ponomarenko et al., 2018; Riabtseva, 2024). As technology advances in agriculture, there is a growing need for precise terminology that accurately reflects modern processes and concepts. Multicomponent terms are essential for detailed descriptions of complex methods and approaches that integrate knowledge from multiple scientific areas. For example, the traditional term *irrigation* has evolved into *real-time precision irrigation system for optimal crop yields and water conservation*, emphasizing the use of technology to optimize water use and improve crop yields, while *pest control* is morphing into *integrated pest management (IPM) strategies* that include a comprehensive approach to minimize the use of pesticides and to protect the environment. These examples show how multi-component terms reflect the integration of precise, science-based methods and interdisciplinary approaches, bringing together agronomy, genetics, ecology and technological innovations. Thus, the development of agricultural terminology not only marks technical progress, but also highlights the importance of sustainable resource management and the need for precise language to describe increasingly complex systems and approaches in modern agricultural practice.

The most common models of multi-component terms in the agronomic literature allow flexible expression of complex scientific concepts, consolidating their elements (adjectives, nouns, verbs, adverbs, numerals). Some terms use prepositions to link components and create more specific meaning (resistance to pests, management of water resources, impact on soil health, reduced amount of organic matter from a high rate of decomposition), multiple modifiers to describe a noun (rapidly growing and high-yielding varieties, environmentally friendly pest control methods), participles (seed-treated plot, an effective farmer-centred mobile intelligence solution), hyphens to form a single unit with a specific meaning (high-value crops, small-farmers, a viable climate-smart option for boosting food production), numerals (five-year crop rotation).

It is worth noting that structural models of terminological units for Russian and English are a well-studied area of linguistics. Multi-component terminological collocations both present complexity due to their structure, and cause translation problems that are typical of the interpretation of simple terms. Even within a complex word combination, terms with more than one meaning can occur (e.g., crop rotation system, cover crop, crop biomass). If the wrong meaning is chosen, it can distort the meaning of the whole construction (Riabtseva, 2022; Sidorova & Popova, 2023).

Individual words within a compound term may not have an exact equivalent in the target language. For example, in the term *no-till cereal-based systems*, the difficulty lies both in the multi-component nature, and in the fact that the term *no-till* itself can be translated differently in different countries as *no-tillage*, *direct seeding*, which creates asymmetry in understanding and interpretation. For example, research in soil science emphasizes that such discrepancies lead to terminological inconsistencies, which represent a major obstacle to the application of research results in practice. Consequently, ensuring clarity and tailoring explanations to the audience is critical to improving communication and achieving consistent understanding (Mironina & Sibiryakov, 2013; Weninger et al., 2024).

In addition, multi-component terminology often contains neologisms that are not yet established terms and lack standard equivalents in other languages (Cabré & Norris, 2023). They can be either fixed (collocations) or flexible, which makes their translation and interpretation still more complex. Fixed phrases like *precision farming techniques* have a predictable structure and meaning, making them easier to translate. In contrast, flexible expressions such as *data-driven agriculture* or *sensor-guided farming* require greater contextual understanding and adaptability.

For accurate meaning, translators must consider scientific context. Machine translators often have difficulty interpreting such contexts, which creates additional hurdles for students. These tools' results are often imprecise and unsuitable for academic purposes. Errors can lead to distorted scientific data and misinterpretations of research outcomes.

In order to expose inaccuracy of machine translation of the specific language an article title on the UK government website (Figure 1) has been processed by four translation systems (Wooordhunt, Yandex, Reverso, and DeepL) with the focus on terminology. Neither grammar nor stylistic mistakes have been taken into consideration, as they are not the object of this research.

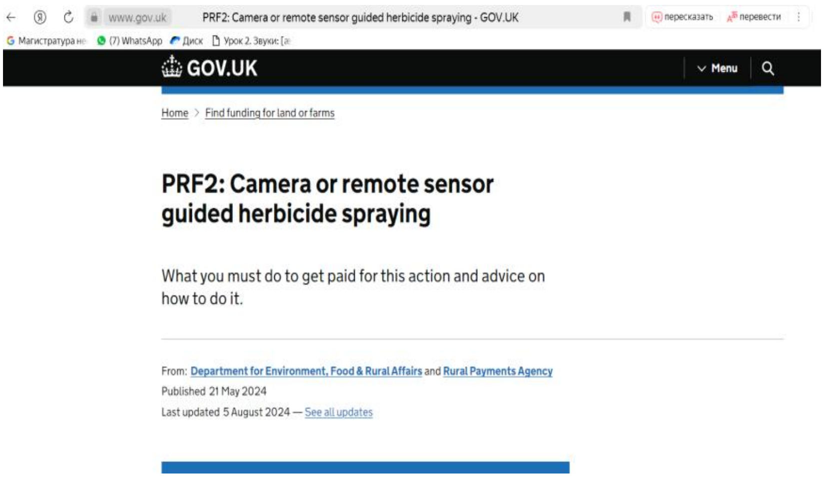

Figure 1. The UK government website

None of the systems decoded the *PRF2* abbreviation and left it untranslated without explanation (Figures 2-5) thus neglecting the operation principal of precision agriculture while *PRF2* stands for precision farming equipment to apply herbicides. Not translating the abbreviation makes the whole system a mere spraying tool.

Wooordhunt (Figure 2) is unable to handle abbreviations and specialized multi-word concepts longer than four words and therefore is not suitable for many of modern multi-component scientific terms.

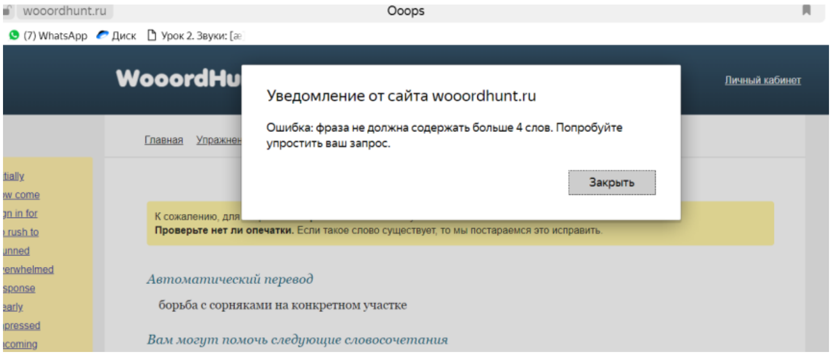

Figure 2. Wooordhunt

Yandex (Figure 3), Reverso (Figure 4) and DeepL (Figure 5) have simplified some terms, namely *guided* to *with the help of* (с помощью) omitting the idea of being equipped with and controlled by an automatic guidance system; *remote-sensor* is reduced to an ordinary observation instrument (датчик), which reacts to certain physical conditions such as heat or light, and which is used to provide information, thus altering the meaning of smart farming practice of automatic decision making.

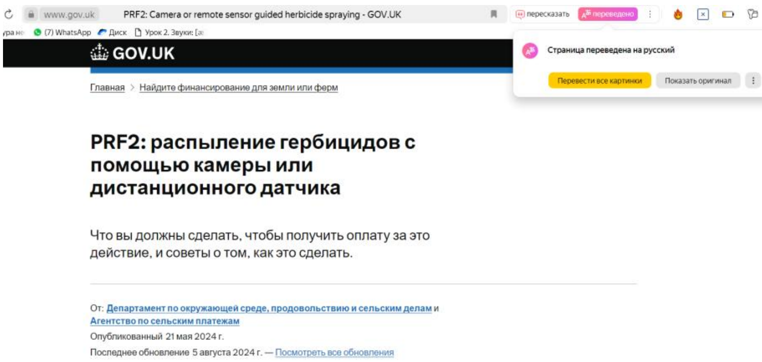

Figure 3. Translation by Yandex neural network

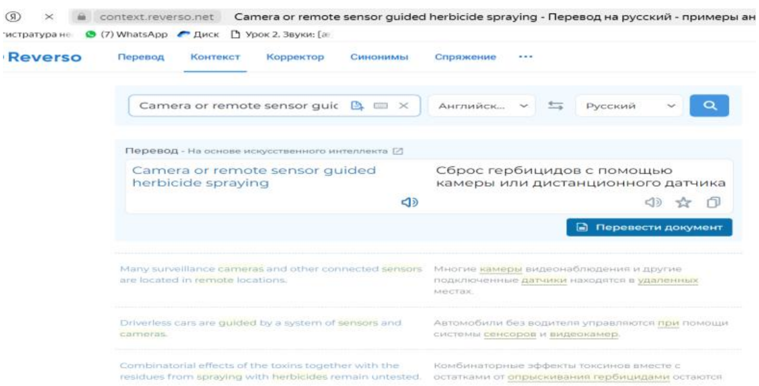

Figure 4. Translation by Reverso

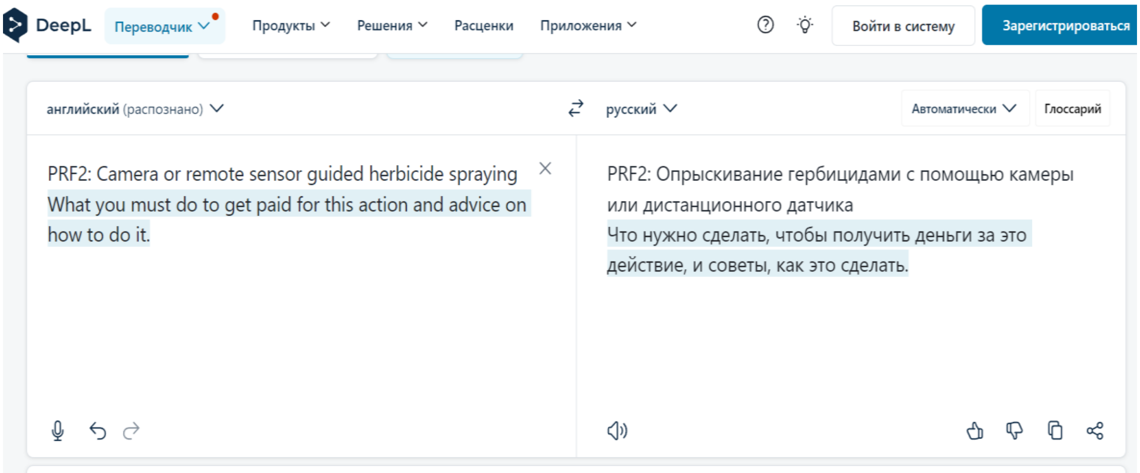

Figure 5. Translation by DeepL

The examples given reflect the fundamental gaps in current students' practices of using digital tools.

The observed trend of replacing traditional paper dictionaries with digital lexicographic databases has significantly changed the way students interact with academic literature. Modern digital dictionaries offer significant potential as 'electronic assistants' (e-assistants) by providing users with personalized answers to queries. AI technologies integrated into such dictionaries automate the processing of lexicographic information. However, these systems remain vulnerable to challenges related to the ambiguity of terms and the complexity of scientific language. Students often encounter limited information when using embedded translators because the definitions provided in pop-up windows are too short to provide a comprehensive lexical picture.

A number of representative examples clearly demonstrate the mistakes made by students with the help of embedded translators regardless of the operational system, smartphone model, etc. The students' interactive translation suggestions have been compared to the translations read by one of the reliable thesauri or dictionaries such as AgroVoc, WIPO Pearl, etc. The comparison results demonstrate how the automated translation reflects on the quality of the students' glossaries. They are presented in tables 1-3. All the mistakes have been grouped according to the possible underlying reasons for them. The most common mistakes occur due to the students' inaccurate command of the terminology in Russian when they translate the terminology themselves without using dictionaries or thesauri (table 1).

Table 1. Students' translations compared to dictionaries and/or thesauri caused by inaccurate command of the Russian terminology

No	Original	Student's translation	Thesaurus/Dictionary entry
1.1.	soil fertility	почвенное плодородие	продуктивность почвы, плодородие почвы
1.2.	small grains	мелкие зерна	зерновые культуры (кроме кукурузы), мелкосемянные злаковые культуры (зерно)
1.3.	alien species	инвазивный вид, чужеродные виды	интродуцированные виды
1.4.	persistence	устойчивость	персистентность
1.5.	soil texture	текстура	механический состав почвы
1.6.	common names	общие названия	общеупотребительные названия
1.7.	gelatinization	гелатификация	гелеобразование
1.8.	agricultural practicies	сельскохозяйственные практики	технологии сельсткохозяйственного производства
1.9.	cover crops	покровные культуры	почвопокровные растения
1.10.	DNA repair	ремонт ДНК	репарация ДНК
1.11.	EMS	EMS	этилметансульфат, эмс

Another notable group contains mistakes due to insufficient command of English. These mistakes occur for a number of reasons: students cannot identify the word combination or the primary word within the word combination, do not know the word combination structure or do not understand the word/sentence structure. It is worth noting that some of these word-combinations are listed neither in dictionaries nor in thesauri, and this is the case when it is very important to understand the structure of the language units and translate them by a human without using machine translation. These examples are given in table 2.

Table 2. Students' translations compared to dictionaries and/or thesauri caused by insufficient command of English

No	Original	Student's translation	Thesaurus/Dictionary entry
2.1.	sheep carrying capacity	продуктивность овец	пропускная способность пастбища
2.2.	pasture species	виды пастбищ	Not listed
2.3.	medium-rainfall region	средний уровень осадков в регионе	Not listed
2.4.	malting and brewering industries	солодовня и пивоварня	Not listed
2.5.	experimental design	экспериментальный план	план эксперимента
2.6.	pulverized	измельчение	Not listed
2.7.	controlled environment agriculture	конролируемое экологичное сельское хозяйство	регулирование параметров окружающей среды, контролируемые условия

Apart from these mentioned mistakes there is still another large group when students pick the first available meaning of the word or word-combination to use it as a glossary entry and then in their translation work. Such examples are very often not listed in the dictionaries or thesauri and may demonstrate both inaccurate command of the Russian terminology and insufficient command of the language and. They are presented in table 3.

Table 3. Students' translations compared to dictionaries and/or thesauri caused by either inaccurate command of the Russian terminology or insufficient command of English

No	Original	Student's translation	Thesaurus/Dictionary entry
3.1.	forest management	управление лесами	лесопользование, ведение лесного хозяйства
3.2.	urban agriculture	домашнее хозяйство	городское сельское хозяйство
3.3.	vertical dimensions	вертикальное измерение	вертикальные размеры
3.4.	variety	разнообразие	сорт (таксон)
3.5.	reset	сбросить	Not listed
3.6.	escape-in-time strategy	стратегия побега вовремя	Not listed
3.7.	gap opening penalty	штраф за открытие пробела	Not listed
3.8.	gap extension penalty	штраф за раширение пробела	Not listed
3.9.	equal flow	равный поток	Not listed
3.10.	decoupled	развязанный	Not listed

Given these challenges, it is clear that graduate students need to develop skills to create glossaries of terminological units and to work independently with bilingual dictionaries and terminological resources. The ability to create glossaries of key terms in their academic disciplines is an essential part of academic training. In order to improve students' academic preparation, systematic training in the use of terminological resources is required. Taking a course in professional foreign language study, which includes the creation and use of bilingual glossaries, as well as a critical analysis of the results of automatic translations, will help avoid errors associated with the improper use of foreign scientific terminology.

While many academic studies focus on teaching aspiring translators and linguists to translate terms, including multi-component ones, there remains insufficient research on training master's students in non-linguistic fields. Students with agricultural and technical specializations often lack the necessary skills to translate technical terms correctly, which negatively impacts their ability to fully utilize international research in their academic work. It is particularly important for them to recognize and correctly interpret compound terms that play a key role in scientific communication.

There is a need to develop new methods and approaches aimed at providing students at non-linguistic universities with the necessary skills to translate and use scientific terminology. Techniques and methods that are effectively used for the training of linguists cannot be directly adapted to the educational process of non-linguistic students, as they often lack a sufficient theoretical linguistic background (Lutfullina, 2021).

One of the most effective solutions to this problem is to teach students how to create English-Russian glossaries for their specific research topics. This not only deepens their understanding of the specific field, but also develops their skills in translating and interpreting scientific terminology (Yuklyaeva, 2020).

Each Master's Degree student explores a narrow topic and requires an in-depth understanding of the terminology characteristic of their field. Teachers need to organize the educational process so that the emphasis is on the independent and individual work of students with foreign language terminology. Such an approach helps to develop skills for in-depth analysis and understanding of technical terms, thereby improving students' professional competence. Importantly, this work is based on specialized text corpora that contain current and contextual information. These corpora may include scholarly articles, reports, monographs, and other sources that reflect the latest advances and trends in the field. Access to contemporary texts allows students to follow changes and evolution of terminology in response to new research and technologies (Valeeva, 2021). Students with insufficient language skills often have difficulty identifying compound terms in specialized texts, hindering their understanding and assimilation of key concepts in their field. Therefore, it seems advisable to teach students to use digital tools for term extraction, which serves the purpose of this study.

One of the most user-friendly platforms is TermoStat Web that allows quick identification of compound terms and their contextual use, which is crucial for mastering technical vocabulary. Research shows that TermoStat Web is comparable in functionality to tools like Sketch Engine and AntConc (Novikova, 2020). By integrating TermoStat Web into the educational process, students can find and interpret compound terms more effectively, improving the quality of their research work. This study proposes to use the TermoStat web platform as an efficient tool for extracting, analyzing and structuring terms, enabling a deeper understanding of subject-specific terminology.

AIM AND OBJECTIVES OF THE STUDY

The paper aims to develop an effective technology for teaching students to utilize digital tools for the identification, analysis, translation, and organization of specialized English vocabulary.

To accomplish this aim, the study sets the following objectives:

- To analyze the potential of digital terminology tools and corpus analysis methods for identifying and structuring specialized terms.
- To propose strategies for teaching students to use TermoStat Web for effective term extraction.
- To outline an approach for guiding students in the creation of English-Russian glossaries using the digital platform Notion.
- To formulate recommendations for integrating these glossaries into translation systems and CAT tools to enhance the precision and consistency of translations.

METHODOLOGY FOR STUDENTS' WORK WITH TERMOSTAT WEB

The methodology comprises sequential stages aimed at developing students’ skills in utilizing digital terminological tools and creating specialized glossaries, thereby enhancing the quality of English-Russian translation of scientific and technical texts.

The process of working with TermoStat Web is divided into successive phases, each of which enables students to examine and organise specialized terms. This structured approach enables a deeper understanding and acquisition of subject-specific vocabulary.

Preparation of the Text Corpus

In the first phase, texts are collected and prepared that summarize the key concepts and topics of the subject area. Students are instructed to select multiple articles, lectures, and academic publications, copy the content, and save it as a single TXT file. This file serves as a corpus – the starting material for the terminological analysis.

Analysis and Grouping of Terms

After uploading the texts to the platform, students receive access to a generated list of terms that can be sorted by frequency of occurrence and other characteristics. It is recommended to first group simple, one-component terms according to their parts of speech that are most frequently used in the text. Grouping terms by parts of speech helps students identify key concepts and attributes within the subject area.

Analysis of Word Formation

Many technical terms are formed by adding suffixes and prefixes. Identifying root words allows students to uncover logical connections between terms and concepts. For example, the discovery of a common root in terms can indicate their semantic proximity and functional relationships. This approach not only deepens students' understanding of terminology, but also improves their ability to analyze and systematize subject-specific vocabulary.

Using Templates

With TermoStat Web it is possible to arrange terms using certain templates. For example, students can group phrases using an adjective + noun template. This makes it possible to examine the meaning that the adjective conveys and to assess how fixed the phrase is in relation to the subject. Thanks to these structuring techniques, the lexical and syntactic patterns that characterize terminology can be examined in more detail (Figure 6).

data-driven	27	39742.42	*data-driven*	Adjective
data-driven agri-tech	1	1471.94	*data-driven agri-tech*	Adjective Common_Noun
data-driven agricultural technology	2	2943.87	*data-driven agricultural technology*	Adjective Adjective Common_Noun
data-driven agriculture	12	17663.26	*data-driven agriculture*	Adjective Common_Noun
data-driven agriculture approach	1	1471.94	*data-driven agriculture approach*	Adjective Common_Noun Common_Noun
data-driven agriculture technology	1	1471.94	*data-driven agriculture technologies*	Adjective Common_Noun Common_Noun
data-driven approach	2	2943.87	*data-driven approach*	Adjective Common_Noun
data-driven decision	1	1471.94	*data-driven decision*	Adjective Common_Noun
data-driven method	1	1471.94	*data-driven methods*	Adjective Common_Noun
data-driven sustainable agriculture practice	1	1471.94	*data-driven sustainable agriculture practices*	Adjective Adjective Common_Noun Common_Noun
data-driven technology	1	1471.94	*data-driven technology*	Adjective Common_Noun
data-intensive field	1	1471.94	*data-intensive field*	Adjective Common_Noun
data-scarce sector	1	1471.94	*data-scarce sector*	Common_Noun Common_Noun
datum	100	23690.88	*data*	Common_Noun
datum access	1	1471.94	*data access*	Common_Noun Common_Noun
datum collection	5	3674.85	*data collection*	Common_Noun Common_Noun
datum collection mean	1	1471.94	*data collection means*	Common_Noun Common_Noun Common_Noun
datum curation	2	2943.87	*data curation*	Common_Noun Common_Noun
datum harvest	1	1471.94	*data harvest*	Common_Noun Common_Noun
datum industry	1	1471.94	*data industry*	Common_Noun Common_Noun
datum integration	1	1471.94	*data integration*	Common_Noun Common_Noun
datum mining	1	1471.94	*data mining*	Common_Noun Common_Noun
https://termostat.ling.umontreal.ca/contexte.php?num=564&file=data8209driven agricul.		1471.94	*data products*	Common_Noun Common_Noun

Figure 6. TermoStat Web

Grouping Terms into Patterns

Grouping terms into structural patterns helps students gain a deeper understanding of the internal logic of terms and identify how specific lexical items accurately describe the core concepts of a text. This approach enables a more systematic exploration of terminology and its functional relationships within the subject matter.

Creating a Glossary

The subsequent step involves organizing the identified terms into a thematic glossary. Students are advised to group terms either by topic (e.g., “soil,” “technology,” “research methods”) or by complexity (e.g., from single-component to multi-component terms). This thematic arrangement allows students to identify logical connections between key terms and better understand their relationships within the broader context of the subject area.

Analyzing Terms in Context

To achieve a comprehensive understanding of a term, students are encouraged to examine its usage in the context. TermoStat Web offers sentence examples (Figure 7) and KWIC (Key Word in Context) (Figure 8), which display sentences containing the selected term. This functionality enables students to observe the use of terms in specialized literature, recognize their typical functions, and discern any connotations they may carry.

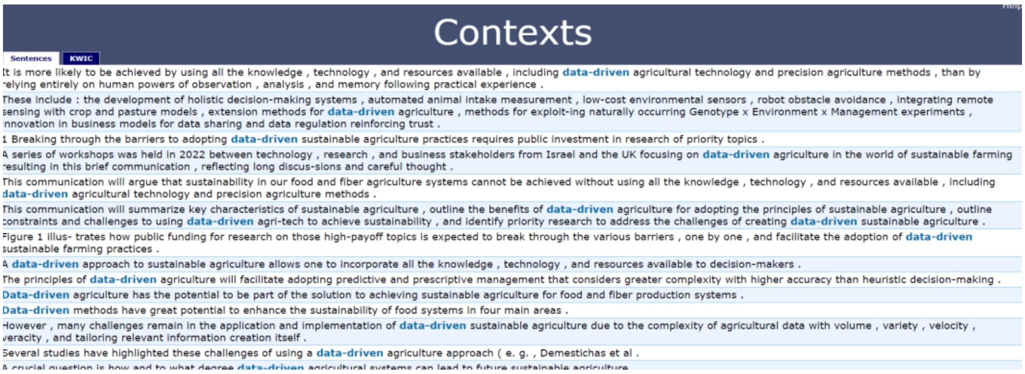

Figure 7. TermoStat Web Sentences Tool

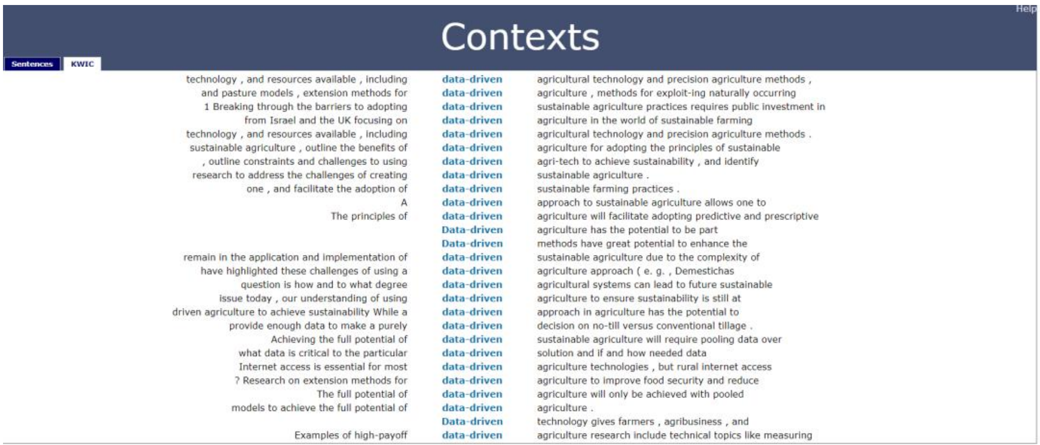

Figure 8. TermoStat Web KWIC (Key Word in Context) Tool

DICTIONARIES AND THESAURI

To create a high-quality English-Russian terminological glossary in the field of agriculture, it is important to teach students how to effectively use specialized dictionaries, thesauri and online resources. These tools not only simplify the process of translating and understanding key concepts, but also help students see relationships between terms, promoting a deeper understanding of the subject matter. In the initial phase, students are encouraged to work with scientific dictionaries of the universities. These dictionaries provide detailed explanations of terms and are therefore particularly valuable for students who want to gain a basic understanding of specialist terminology.

In later phases, the focus shifts to multilingual glossaries developed by international organizations, such as:

FAO Term Portal: This portal provides access to official terminology of the Food and Agriculture Organization of the United Nation (FAO), including precise translations and definitions, which are crucial for ensuring consistency and accuracy in agricultural terminology.

AGROVOC: AGROVOC is a multilingual thesaurus developed by FAO, covering a broad range of agricultural and related fields. It facilitates the exploration of terminological relationships and enables students to analyze connections between terms across different languages and disciplines.

As students engage with specialized terminology, they can utilize a range of resources to gain a comprehensive understanding of each term. For instance, comparing AGROVOC with the FAO Term Portal provides complementary insights into both the meaning and usage of terms.

The FAO Term Portal serves as a dictionary, offering precise definitions and official translations of terms. Its primary objective is to standardize language by providing authoritative FAO-approved terminology, ensuring accuracy and consistency across contexts. This resource is particularly critical for validating and aligning agricultural terminology with international standards.

Conversely, AGROVOC facilitates a broader exploration of terms by presenting related concepts and revealing the intricate relationships among terms within specific subject areas. This functionality is especially beneficial for examining connections in highly specialized fields, enabling a deeper understanding of the conceptual framework underlying the terminology (See Figures 9-10).

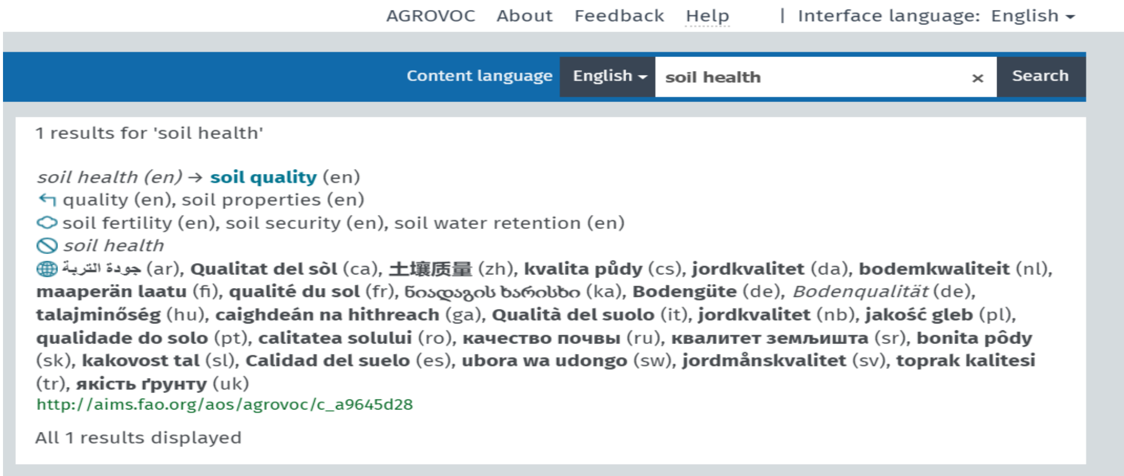

Figure 9. AGROVOC

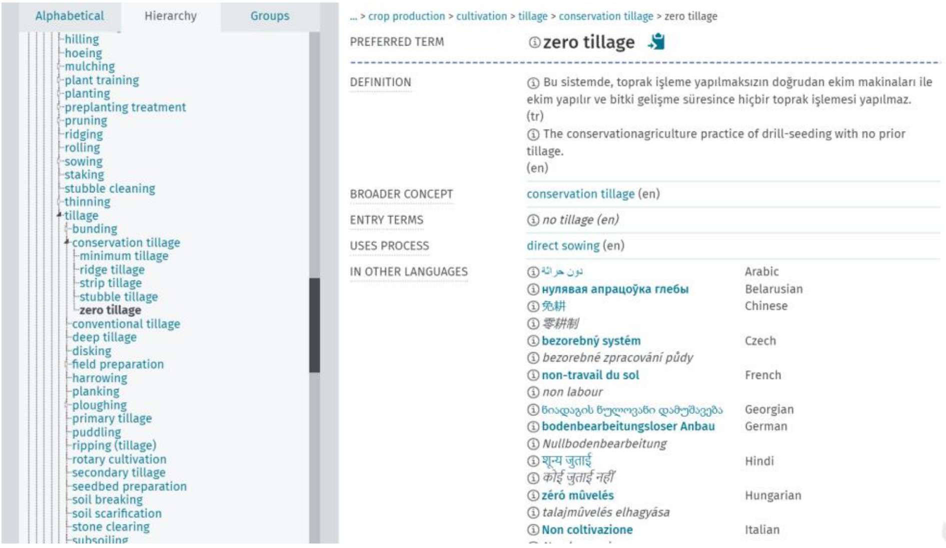

Figure 10. AGROVOC

DIGITAL TOOLS TO CREATE GLOSSARIES

After being introduced to databases such as AGROVOC and WIPO Pearl, students create their own glossary using the digital tool Notion. With Notion, students can structure and efficiently manage the information they collect, creating a dedicated database for their glossary. The tool supports adding translations, definitions, related terms, examples, and thematic categorization of terms. Additionally, students can link from their Notion glossary to external websites or resources to provide additional context and further reading material or to cite their definitions. Notion also offers a variety of data visualization formats and the ability to collaboratively edit and update the glossary in real time. This makes it a valuable resource for academic and research activities. The English-Russian glossary created in Notion can serve not only as a learning tool, but also as a basis for improving the quality of translations in a subject area. In addition, the glossary can be integrated into professional translation systems such as CAT (Computer-Assisted Translation) tools as well as online translators such as Yanlex and DeepL. This integration allows standardized terms to be automatically applied during translation, minimizing the risk of errors and improving conceptual accuracy.

AGROVOC-BASED TASKS

Click on the chosen entry to see its relationships. Pay attention to:

- ✓ Preferred Term: AGROVOC's standardized term for the concept.
- ✓ Definition
- ✓ Hierarchy: broader terms and narrower terms. This shows you how this term fits into the bigger picture.
- ✓ Related Terms: conceptually connected terms. These links expand the scope of your exploration.

- ✓ Translations: Find Russian equivalents.
- ✓ Compare: Russian and English definitions, broader and narrower terms, related terms.

Another valuable resource for clarifying the terminology that we introduce to students is WIPO Pearl (See Figure 11). WIPO Pearl is a terminology database developed in 2014 by the World Intellectual Property Organization (WIPO) to ensure the accurate and consistent use of scientific and technical terms in the ten languages used in the Patent Cooperation Treaty (PCT) patent system. Experienced linguists and terminologists at WIPO review and assign reliability scores to terms derived from international patent applications filed under the Patent Cooperation Treaty (PCT). The database covers 29 subject areas, including emerging areas such as quantum computing and medical robotics. Each term is accompanied by examples and has a unique URL to access the full terminology dataset.

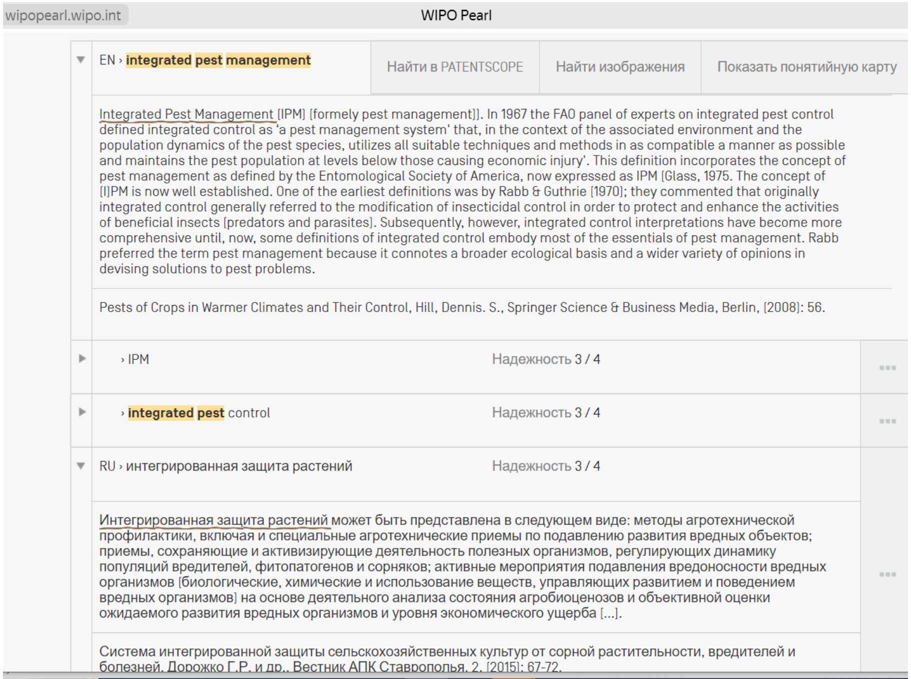

Figure 11. WIPO Pearl

CONCLUSION

To sum it up, it is worth taking into consideration that usually non-linguistic students have no or little interest in language learning as it is traditionally a difficult task for them often regarded as a tedious and error-prone one. The rise of digital translation technologies has opened up new opportunities, which unfortunately are often considered by the students as an exemption of normal learning routine. However, as it has been shown in the present paper the technology can at the same time be both motivating and helping to cope with difficult academic and scientific texts.

The research has presented an overview of a number of modern dual-purpose digital tools – of glossary compilation, on the one hand, and learning specific terminology, on the other hand. The use of these instruments allows students to acquire the needed language skills more efficiently. The methodology outlined in this article provides a comprehensive approach to students' work with specialized terminology, using various digital tools of different nature providing learners with ample opportunity to handle a text as a whole rather than its isolated units as it used to be in traditional foreign language acquisition. Being versatile and multipurpose, giving a wider scope of the meaning than a conventional dictionary, all these tools permit to overcome the usual fear to face and reluctance to process a long foreign language text provided careful guidance is given.

It is recommended to use all the reviewed tools, namely TermoStat Web, AGROVOC, WIPO Pearl, and Notion as a complex, in the order described in the paper. By systematically preparing a text corpus, analyzing and grouping terms, exploring word formation, and employing templates, students enhance both their academic knowledge and translation skills.

The combination of TermoStat Web for term extraction, AGROVOC/WIPO Pearl for verification, and Notion for glossary organization addresses distinct aspects of terminology acquisition. TermoStat's corpus analysis capabilities proved particularly valuable for identifying recurring term patterns in agricultural literature, while AGROVOC's relational structures helped students contextualize concepts.

Our framework strategically combines three types of digital tools, each serving distinct complementary functions. TermoStat Web extracts high-frequency and field-relevant terminology directly from agricultural texts /corpora, revealing actual usage patterns. By exposing these patterns, TermoStat engages students in active terminology processing rather than passive term reception.

AGROVOC and WIPO Pearl provide authoritative verification through standardized definitions, addressing the frequent inaccuracies in machine-translated terms. AGROVOC's hierarchical trees help students visualize relationships between concepts (broader/narrower terms, related concepts), while WIPO Pearl's discipline-specific definitions clarify ambiguities in emerging terms. This step is critical when applying tools like Yandex or DeepL.

Notion offers flexible organization of verified terms into personalized, searchable glossaries.

This approach directly targets the weaknesses observed in student practices. By forcing engagement with corpus-derived terms and curated databases, students develop critical evaluation skills and create reusable, research-specific resources that grow with students' academic progress.

Among the advantages of the approach, the integration of digital tools into terminology teaching has fundamentally transformed the landscape of English for Specific Purposes (ESP) instruction. Technology extends human pedagogical capacities in remarkable ways that were not possible through traditional methods. While a generation ago learners had to compile terms from paper dictionaries, today's students can map entire conceptual networks across thousands of documents, identifying subtle variations in usage.

However, these technological advantages come with significant intellectual responsibilities, which result in certain shortcomings, namely blind trust in and excessive dependence on the digital tools, overlooking the specialized knowledge needed to verify terminological accuracy thus potentially leading to serious miscommunications in international research collaborations. Our research shows that careful guidance provided by the teacher enables students to take more responsibility and to rely on their own effort.

Looking ahead, the challenge for ESP instructors will be to maintain this delicate balance. As generative AI systems become more sophisticated, they generate significant instructional dilemmas for foreign language acquisition. The solution, as our methodology suggests, lies in redesigning learning experiences and providing learner-led investigations based on digital tools. By training students to critically evaluate digital outputs against authoritative sources, we develop professionals capable of informed tool usage.

REFERENCES

Alipichev, A. Yu., Porchesku, G. V., & Sergeeva, N. A. (2023). Special'naya leksika v nauchno-populyarnom tekste i ee perevod [Translation of Specialized Vocabulary in Popular Science Writing]. *Vestnik Cherepoveckogo gosudarstvennogo universiteta, 2*(113), 7-19. https://doi.org/10.23859/1994-0637-2023-2-113-1

Cabré, T., & Norris, S. (2023). *Terminology: Cognition, Language and Communication*. John Benjamins Publishing Company. https://doi.org/10.1075/ivitra.36

Jolley, J. R., & Maimone, L. (2022). Thirty years of machine translation in language teaching and learning: A review of the literature. *L2 Journal: An Electronic Refereed Journal for Foreign and Second Language Educators, 14*(1). https://doi.org/10.5070/L214151760

Kartasheva, A. (2024). Dialogue as Autocommunication On Interactions with Large Language Models. *Technology and language, 5*(2), 57-66. https://doi.org/10.48417/technolang.2024.02.05

Leitchik, V. M. (2012). *Terminovedenie. Predmet, metody, struktura* [Terminology. Subject,Methods, Structure]. Librokom.

Lotte, D. S. (1982). *Voprosy` zaimstvovaniya i uporyadocheniya inoyazy`chny`kh terminov i terminoe`lementov* [Issues of Borrowing and Regulation of Foreign-Language Terms and Term Elements]. Nauka.

Lutfullina, G. F. (2021). Obuchenie studentov neyazykovyh vuzov strukturnomu metodu perevoda terminov v tekstah ekologicheskoj tematiki [Teaching Structural Method of Ecological Terms Translation to Non-Linguistic Students]. *Philology. Theory & Practice*, *14*(3), 953-958. https://doi.org/10.30853/phil210070

Malyarchuk-Proshina, U. O., & Burlachenko, K.A. (2020). Inostranny`e zaimstvovaniya v nauchno-tekhnicheskoj terminologii [Foreign borrowings in scientific and technical terminology]. *Tendenczii razvitiya nauki i obrazovaniya*, *58*(10), 44-50. https://doi.org/10.18411/lj-02-2020-207

Marinoni, G., & Pina Cardona, S. B. (2024). *Internationalization of Higher Education: Current Trends and Future Scenarios.* International Association of Universities

(IAU). https://www.iau-aiu.net/IMG/pdf/2024_internationalization_survey_-_executive_summary.pdf
Mironina, A. Yu., & Sibiryakov, O. N. (2013). Pragmaticheskij aspekt perevoda obshchestvenno-politicheskih tekstov [Pragmatic Aspect of Social and Political Texts Translation]. *Vestnik Vyatskogo gosudarstvennogo gumanitarnogo universiteta*, *2*(2), 114-117.
Novikova, A. A. (2020). Sravnenie instrumentov Sketch Engine i TermoStat dlya izvlecheniya terminologii [Sketch Engine and TermoStat tools for automatic term extraction]. *International Journal of Open Information Technologies*, *8*(11), 73-79.
Ponomarenko, L. N., Mishutinskaya, E. A. & Zlobina, I. S. (2018). Lingvostilisticheskie osobennosti medicinskih tekstov v perevodcheskom aspekte [Linguistic and Stylistic features of medical texts in the translation aspect]. *Gumanitarnaya paradigm*, *1*(4), 9-14.
Riabtseva, N. K. (2022). Contemporary Terminological Problems in a Cross-linguistic Perspective. *Nauchnyi dialog*, *11*(6), 123-139. https://doi.org/10.24224/2227-1295-2022-11-6-123-139
Riabtseva, N. K. (2024). Cross-Linguistic Scientific Communication, Contemporary Digital Terminological Neologisms in English, and Translation Issues. *Nauchnyi dialog*, *13*(5), 124-139. https://doi.org/10.24224/2227-1295-2024-13-5-124-139
Rothwell, A., Moorkens, J., Fernández-Parra, M., Drugan, J., & Austermuehl, F. (2023). *Translation Tools and Technologies*. Routledge. https://doi.org/10.4324/9781003160793
Ryabchikova, V. G. (2024, March 22). Ponyatie "otraslevoj tekst", osobennosti ego struktury i perevoda [The concept of industry-specific text, features of its structure and translation]. In *Teaching Foreign Languages in a Multicultural World: Traditions, Innovations, Prospects*. *Proceedings of the VI International Scientific Practical Conference]* (pp. 152-155). BSPU.
Schmidt, T., & Strasser, T. (2022). Artificial intelligence in foreign language learning and teaching: a CALL for intelligent practice. *Anglistik: International Journal of English Studies*, *33*(1), 165-184. https://doi.org/10.33675/ANGL/2022/1/14
Sidorova, E. N. & Popova, L. G. (2023). Leksikograficheskaya reprezentaciya ponyatijnogo komponenta koncepta “gardening” [The concept of “gardening”: lexicographic representation of its notional component]. *Litera*, *11*, 206-213. https://doi.org/10.25136/2409-8698.2023.11.68864
Siu, S. C. (2023). ChatGPT and GPT-4 for professional translators: exploring the potential of large language models in translation. *SSRN*, *4448091*, 1-36. http://dx.doi.org/10.2139/ssrn.4448091
Valeeva, E. E. (2021). Obuchenie professional'noj terminologii na zanyatiyah po anglijskomu yazyku [Training for Professional Terminology in English]. *Modern Problems of Science and Education*, *1*. https://doi.org/10.17513/spno.30445
Vigna-Taglianti, J. (2024). AI-Generated Images as a Teaching Tool in Foreign Language Acquisition. *Technology and Language*, *5*(3), 85-105. https://doi.org/10.48417/technolang.2024.03.07
Volgina, M. Yu. (2013). Perevod terminov kak klyuchevy`kh edinicz speczial`nogo

teksta [Translation Terms as the Key Units of the Special Text]. *Perspectives of Science and Education*, *6*, 170-175.

Weninger, T., Ramler, D., Bondi, G., Asins, S., O'Sullivan, L., Assennato, F., ... & Klimkowicz-Pawlas, A. (2024). Do we speak one language on the way to sustainable soil management in Europe? A terminology check via an EU-wide survey. *European Journal of Soil Science*, *75*(2), e13476. https://doi.org/10.1111/ejss.13476

Yuklyaeva, E. A. (2020). Ispol'zovanie osobennostej perevoda novejshih anglijskih finansovyh terminov pri obuchenii inostrannomu yazyku v finansovo-ekonomicheskom vuze [Using Translation Peculiarities of Newest English Financial Terms in Teaching Foreign Languages at Universities for Economics and Finance]. *Vestnik of Moscow State Linguistic University. Education and teaching*, *2*(835), 103-117.

Zaripova, A., Saenko, N., Shvachkina, L., Sultanova, I., & Rodionova, V. (2024). Formation of Coronavirus Pandemic Terminology in the German language as a Reflection of the New Socio-cultural Situation in the World. *Brazilian Journal of Law and International Relations*, *1*(43), 526-540. http://dx.doi.org/10.21902/Revrima.v1i43.6779

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