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METAPHORICAL NEOLOGISMS IN ENGLISH TERMINOLOGY OF SCIENCE AND TECHNOLOGY

Metaphor is now widely recognized as an essential part of the scientific discourse, but research on the lexical and cognitive mechanisms of metaphorical terminology formation remains limited. The article explores metaphorical words and word combinations in the novel terminology of science and technology that has emerged in English in the last three decades. By monitoring resources for neologism tracking (such as WordSpy) and updates of the Oxford English Dictionary as well as analyzing specialized literature, we identified over thirty lexical and semantic neologisms based on metaphors. Computer science and environmental sciences were found to be particularly prone to institutionalizing metaphor-based terms, either via coining new units or repurposing existing ones. Some of the identified terms are formed by expanding conventional metaphors (e.g., dark pattern, filter bubble, blue carbon), while others are more creative, drawing upon the source domains of the animal world (e.g., climate canary, black swan) and natural phenomena and systems (e.g., cloud computing, data lake, digital ecosystem). The most remarkable finding is that metaphorical terms frequently launch a chain reaction of new coinages derived by analogy (cloud computing – fog computing, mist computing, etc.; ecological footprint – carbon footprint, plastic footprint, etc.). This finding confirms the powerful role of analogy in neological word-building even with respect to metaphorical terms.
Keywords: *metaphor, science, technology, lexical neologism, semantic neologism.*

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МЕТАФОРИЧНІ НЕОЛОГІЗМИ В АНГЛОМОВНІЙ ТЕРМІНОЛОГІЇ НАУКИ І ТЕХНОЛОГІЙ

Метафора сьогодні широко визнана як невід'ємна частина наукового дискурсу, але досліджень лексичних та когнітивних механізмів формування метафоричної термінології бракує. Ця розвідка зосереджена на метафоричних словах та словосполученнях в новітній термінології науки і техніки, що з'явилася в англійській мові за останні три десятиліття. Шляхом моніторингу ресурсів для відстеження неологізмів (наприклад, WordSpy) та оновлень Оксфордського словника англійської мови, а також аналізу спеціальної літератури, ми виявили понад тридцять лексичних та семантичних неологізмів, заснованих на метафорах. Було виявлено, що особливо схильними до інституціоналізації термінів на основі метафор є комп'ютерні науки та науки про навколишнє середовище – як шляхом створення нових одиниць, так і шляхом переосмислення вже існуючих. Частина виявлених термінів утворена шляхом розширення традиційних метафор (наприклад, dark pattern, filter bubble, blue carbon), тоді як інші є більш креативними та черпають образи з таких сфер-джерел як тваринний світ (наприклад, climate canary, black swan) і природні явища та системи (наприклад, cloud computing, data lake, digital ecosystem). Найбільш показовим є те, що метафоричні терміни часто запускають ланцюгову реакцію утворення нових термінів з аналогічною структурою (cloud computing – fog computing, mist computing тощо; ecological footprint – carbon footprint, plastic footprint тощо; black swan – white swan, black elephant тощо). Цей факт підтверджує магістральну роль аналогії в неологічному словотворенні навіть у межах метафоричних термінів.
Ключові слова: *метафора, наука, технології, лексичний неологізм, семантичний неологізм.*

Introduction. Over the last decades, science and technology have been developing at break-neck speed. Their impressive advances call forth the introduction of countless new terms (lexical neologisms) or repurposing of already existing words and phrases for new meanings (semantic neologisms). Typically, the development of scientific terminology is considered quite a tedious topic for linguistic analysis, since it is mostly straightforward and unimaginative. However, a large share of scientific terms demonstrates striking playfulness and linguistic creativity. A vivid and often-cited example is the physics term *quark*, coined by the physicist Murray Gell-Mann in 1963 to refer to the newly discovered indivisible particle found within protons and neutrons. The scientist derived the term from a line in James Joyce's novel "Finnegans Wake": "Three quarks for Muster Mark!" He selected this term partly for its whimsical quality, but also because there were three types of quarks known at that time (now there are six). As a further example, the names of relatively new interdisciplinary fields, cliometrics and cliodynamics (approaches to historical inquiry that emphasize quantitative analysis and modeling to understand economic and social phenomena), are derived from Clio, the muse of history in Greek mythology. The history of science is now unimaginable without such metaphor-based terms as *Schrodinger's cat,* *Einstein's spacetime fabric, Maxwell's demon, Darwin's tree of life, Watson and Crick's double helix*, which have played significant role in shaping our understanding of scientific concepts and phenomena.

As noted by N. Kompa (2022: 28), metaphor is "a driving force behind language change, as when we encounter a new situation we tend to conceptualize it by means of familiar vocabulary". Considered in the broadest sense, metaphor involves discussing one object in terms typically applied to another, quite a different object (Reynolds, 2022: 2). The grounds for philosophical and, later, linguistic exploration of metaphor in science were laid by Max Black (1962) and Mary Hesse (1966). The profound epistemic role metaphor plays in scientific terminology and development of scientific thought as such has been explored from various perspectives by Brown (2003), Finatto (2009), Haack (2019), Hoffman (2018), Kövecses (2002), Montuschi (2017). Discipline-specific studies of metaphorical terminology have been presented by Temmerman (2001), Reynolds (2022) (both focus on life sciences), Pulaczewska (2011) (physics), Mahutian (2015) (chemistry), Kramar & Ilchenko (2021) (cosmology and astrophysics), Hrybinyk et al. (2022) (geology and geodesy). These studies provide ample evidence for the pervasiveness of metaphor in various fields of science and justify the need for a deeper understanding of its implications. In addressing this issue, scholars quite often draw upon the conceptual metaphor theory, developed by G. Lakoff and M. Johnson, as their research framework. Analyzing the source and target domains of the underlying scientific metaphors more profoundly enables them to trace how metaphors influence scientific models, theories, and paradigms. In his recent work, "Understanding Metaphors in the Life Sciences" (2022:13), A. Reynolds quite emphatically points out four major functions of metaphor in science: 1) rhetorical (facilitating communication between experts and non-experts); 2) heuristic (stimulating the development of new hypotheses); 3) cognitive (promoting analogical reasoning); 4) the function of a technological instrument leading to material changes in the essence of the object or process represented with a metaphor.

At the same time, metaphor's use in science can be fraught with misunderstandings and lack of accuracy. Based on the realm of life sciences, studies have demonstrated how common metaphorical models occasionally constrain the development of scientific reasoning, perpetuate misconceptions and even become entangled with conflicting sociopolitical ideologies (McLeod & Nerlich, 2017; Taylor & Dewsbury, 2018). This factor seems to additionally substantiate the need for in-depth analysis of metaphorical language in science from all perspectives, including the linguistic one.

The relevance of our study is grounded in the incessant linguistic interest in metaphor, on the one hand, and fast-moving development of new terminology in science and technology, on the other hand. As technological advances and complex scientific concepts increasingly become an inalienable part of our everyday lives, it is crucial to ensure their proper nominalization and communication both within the academic community and beyond it – in "layperson" popularizations.

There is a lack of linguistic investigation that would provide a picture of the role and patterns of metaphor use in the newest terminology across various fields of science and technology. The purpose of our article is thus to identify metaphorical neologisms in these domains, analyze their structural and semantic features and dive deeper into the implications of these terms for respective fields. Particular attention will be paid to cases where metaphorical denomination engenders some extent of controversy or debate about the accuracy and relevance of such conceptual mappings.

The study is based on the terms that have emerged from the turn of the century up to now. These units were identified as a result of continuous monitoring of resources for neologism tracking: WordSpy, Cambridge Dictionary Blog, and Oxford English Dictionary updates. Many of the neologisms under study were included in the recently published dictionary of neologisms by Kramar (2022). The key findings are summarized below.

Results and Discussion. We revealed that, within terminology of science and technology, one metaphorical term serves as a ground for new terms that draw upon the same source domain. The most illustrative case is *black swan*, which originated in economics but gradually permeated different areas of science and even impacted the metatheory of science to some extent. It was first used by Nassim Nicholas Taleb in his 2001 book *The Black Swan: The Impact of the Highly Improbable* to refer to an unexpected, extremely improbable event that has far-reaching repercussions. The author alludes to an ancient Latin saying implying that something is as impossible as a black swan. The fact that black swans were eventually discovered in the 17th century made it a vivid example of how seemingly impossible things may turn out to be true. Based on this term, a few others were subsequently modeled: *gray swan* – a significant event that is considered unlikely, *white swan* – an easily predictable event. In risk management and decision theory, however, this play on words went even further to include other animals: the term *black elephant* (a hybrid of *black swan* and *elephant in the room*) refers to a highly probable detrimental event that remains ignored for a long time (much like today's ecological and climate hazards), *gray rhino* – to an obvious risk that is denied or not addressed properly, *black jellyfish* – to a highly complex and rapidly evolving process that is hard to manage. Therefore, one nuclear term derived from the source domain of animal world brought forth a series of similar terms drawing upon this domain. More importantly though, it stimulated revisiting of the concept of risks and probabilities from a new perspective, influencing the development of economic and environmental theories.

Within environmental sciences, striking productivity and similar heuristic value is exemplified by the metaphorical mapping "negative impact as footprint". Thus, back in the 1990s, the term *ecological footprint* was coined (rather serendipitously, as explained in Safire, 2018) to denote the area of land and water needed to produce the resources and absorb the waste generated by a particular population. The same model was used a few years later to create *carbon footprint,* which represents the amount of carbon dioxide emissions associated with human activities, contributing to climate change. It is now well-known even among laypeople. Later on, analogous terms *water footprint* and *plastic footprint* were introduced to quantify the amount of water consumption and plastic pollution associated with a person or an organization. As concerns about issues such as climate change, resource depletion, environmental degradation, and social inequality intensified, there was a growing emphasis on the importance of not only reducing negative impacts but also fostering positive actions. As a natural counterpart of the "footprint" metaphor, the mapping "positive impact as handprint" has emerged. Thus, *ecological handprint* (coined around 2005-2010) represents the favorable actions taken by individuals or organizations to mitigate their environmental impact and contribute to sustainability. Once again, the chain reaction ensued, with *carbon handprint* and *water handprint* now used widely both in business environment and in academic venues. Incidentally, the footprint metaphor can also be found in the field of technology, best exemplified in the term *digital footprint* (the trail of data users leave behind when interacting with digital platforms, devices, and services). In this case, however, there is no evaluative aspect, as the term refers to all kinds of data, without differentiating between “good” and “bad”. Interestingly, a synonym to *digital footprint* is *digital shadow* – also metaphorical, but based on another mapping – “indirect representation as shadow”.

In novel computer science terminology, the metaphorical term that stimulated the most ramifications is *cloud computing*. It refers to the delivery of computing services over the internet (represented as the "cloud") for greater efficiency. Dwelling upon the same foundation are such terms as *cloud bursting* (a situation where an organization's local resources are enhanced with additional computing resources from an external cloud provider), *cloud migration* (moving data and applications from on-premises infrastructure to cloud infrastructure) and *cloudlet* (a small cloud datacenter). Moreover, this metaphor paved the way for the emergence of *fog computing* (coined in 2008) referring to data processing performed from nearby devices instead of the cloud. Also, the latest developments in this field have been dubbed *mist computing, dew computing, fluid computing* – all based on the overarching metaphor of atmospheric phenomena, further expanding the landscape of distributed computing paradigms. Moreover, the cloud metaphor turned out to be so popular that it went beyond the realm of IT and computer science and was picked up in economics, where the term *human cloud* is now often applied to human labor accessed through online platforms as a service.

It is important, though, that the proliferation of analogous terms stemming from the same metaphorical model may not always be felicitous. For instance, in IT the representation of “data as water” is extremely common. As such, it is a manifestation of ontological metaphor, presenting an abstract idea as something concrete and tangible. In 2010 the term *data lake* was coined to denote a big amount of data accessible in its raw format. It is grounded in the idea that a data lake is analogous to a large body of water, where various streams of data flow into a single repository, much like streams and rivers feeding into a lake. Since that time, a host of other terms have emerged for “data bodies of water”, such as *data pond* (regionally structured data repositories), *data puddle* (a single-purpose small dataset), *data swamp* (data repository with poor management and low quality of data), and even *data lakehouse* (a blend of *data lake* and *data warehouse*). However, some of these terms are criticized in the IT community as they arguably stretch the “data as water” metaphor too far (Das, 2022). The spread of such terminology reflects the shift in general perception of data in the industry: while in the 2010s a common catchphrase was “data is the new oil” (coined by the data scientist Clive Humby in 2006), today IT leaders explicitly call it “the new water” (Chou, 2023) due to its abundance and fluid nature (fossil fuels’ falling from grace, presumably, has also played a role here).

The above-mentioned terms demonstrate the fruitfulness of natural phenomena and objects as the source domain for computer science terminology. At a much larger scale, the realm of nature is harnessed in the term *digital ecosystem* meaning the interconnected network of digital platforms, services, users, and data that interact within a specific online environment. By applying the concept of an ecosystem to the digital world, *digital ecosystem* implies that various digital components (e.g., software, hardware, networks, users) interact and depend on each other within a complex and interconnected system. Like a natural ecosystem, the digital ecosystem involves interdependencies, competition, adaptation, and coexistence among its elements. However, this term has been objected to criticism from some scholars as it presumably blurs crucial and ideologically important distinctions between the two domains being compared. For example, M. Krivý (2023: 8) notes that the metaphor of “digital ecosystem” has prioritized the imperative of adapting to – and downplayed the possibility of challenging – our erratic digital capitalism.” Another IT term that often comes under attack as a misnomer is *Internet of Things*, however straightforward it sounds. It was coined at the turn of the century to denote the interconnectedness of multiple everyday devices through the internet, enabling them to send and receive data. The metaphor suggests a network where physical objects, or "things", are interconnected in a similar way that people are connected via the internet. Interestingly, this term is often criticized as a misnomer, since the devices do not need to be connected to the public Internet, only to a network with a unique ID or address (Dey et al., 2018: 440). Thus, basically, the object process behind the name *Internet of Things* has little to do with the Internet as such. Likewise, some debate arises around the term *hallucinations*, a semantic neologism that acquired the meaning of misleading or utterly false information provided by chatbots after the rollout of ChatGPT in 2022 and its sensational popularity. Essentially, it compares such answers to sensory perceptions resulting from a mental illness. Some experts believe that it excessively personifies chatbots and falsely attributes them with agency they do not really have (Edwards, 2023). In this way, the responsibility is implicitly shifted away from the developers behind these powerful chatbots. Such reflections underscore the importance of scrutinizing the cognitive implications of metaphors underlying widespread terms as they may create misconceptions or reinforce unproductive lines of thought or behavior.

Another trend we have noticed is that metaphorical terminology often draws upon conventional metaphors, only adding a spin to them. For instance, the term *filter bubble* refers to the phenomenon in which an individual is increasingly isolated from information that contradicts their beliefs or perspectives, as a result of personalized algorithms selectively presenting content that aligns with their existing preferences, interests, or viewpoints. This concept was popularized by Eli Pariser in his book *The Filter Bubble: What the Internet Is Hiding from You* (2011). This metaphorical representation underscores the idea of being enclosed within a limited informational space, where only certain types of content are allowed to permeate. Essentially, *filter bubble* is based on quite a common representation of isolation as a bubble, but in this case intellectual isolation is foregrounded. In a similar vein, the novel terms *dark pattern* (a website design feature that makes users do some actions they do not intend to do originally), *dark social* (online interactions via messengers that cannot be traced), *darknet* (encrypted and unregulated part of the internet that can only be accessed via special clients) are based on quite a widespread and customary conceptualization of “secret as dark”. In the field of environmental sciences, metaphorical representations of various colors are commonly exploited in terminology formation. In particular, terms such as *green / blue / gray infrastructure*, *green economy*, *blue carbon*, *blue economy*, etc., are based on conventional metaphorical representations of sustainable as green, related to water bodies as blue, and common urban structures as gray.

In the area of climate science (where the terminology has evolved by leaps and bounds recently), the term *tipping point* is now in the limelight. While it has existed roughly from the middle of the 20th century in the meaning of a critical moment when decisions have to be taken, in climate discourse, it has received the connotation of danger and catastrophe, denoting a threshold beyond which climate change becomes irreversible. It serves to emphasize the fact that relatively small changes in external forcing, such as greenhouse gas emissions, can trigger large-scale catastrophic changes in the environment. The underlying metaphor evokes images of balance and stability, thus implying that the climate system is delicately balanced, and once a tipping point is reached, the balance is disrupted, leading to significant shifts in climate patterns. As argued by van der Hel, Hellsten, & Steen (2018), starting with 2007, this phrase became “the theory-constitutive metaphorical model” (p. 610) in climate science, and starting with 2011, it became conventional in the media discussion of climate change to the extent that its metaphorical origin was forgotten. Thus, *tipping point* was suited for various communicative purposes and provided a frame that was comprehensible for experts and laymen alike, emphasizing the urgency of the matter.

Another climate-related term that is catchy enough to feature both in academic articles and media headlines is *climate canary*. It refers to a species, ecosystem, or natural phenomenon that is particularly sensitive to climate change and can serve as an indicator of broader impacts. It is basically a play on the long existing idiom *canary in a coalmine*, stemming from the historical practice of coal miners bringing caged canaries into coal mines to test for the presence of toxic gases. Since canaries are particularly sensitive to them, their distress or death served as strong warning for miners. In this case, we observe repurposing with a partial lexical modification of the term to better suit the new purpose. A similar process is exemplified in the IT term *cyberbalkanization* (alternative spelling – *cyber-balkanization*) that indicates the fragmentation or division of the digital realm, particularly the internet, into separate, isolated, or segregated entities, often along ideological, cultural, or political lines. It is based on the metaphorical reinterpretation of the geopolitical notion of "Balkanization," referring to the fragmentation or division of a region or entity into smaller, often hostile, units. Blending “balkanization” with “cyber” additionally clarifies the two domains being compared.

One more influential scientific term where metaphorical mapping is reflected in the process of lexical blending is *technofossil*. Coined in 2014 by Professor Jan Zalasiewicz and colleagues, it combines the words "technology" and "fossil" to describe objects of human-made technology preserved in the environment for a long time, drawing a parallel with biological fossils, which endure in geological formations. While traditional fossils are remnants of ancient organisms preserved in rock layers, *technofossils* refer to artifacts or traces of human technology that become preserved in the geological record. These could include items such as plastics, concrete structures, electronic waste, or other durable materials created by human activity. The term highlights the idea that human technological activity has left a lasting imprint on the planet, similar to the geological impact of natural processes over millennia. Therefore, the unique challenges of the Anthropocene epoch, such as the exacerbating climate crisis and pervasive impact of technology, are captured in the scientific terminology by means of metaphorical mappings that often become theory-constitutive and generate further discussion within the discipline or across disciplines.

Conclusion. Since the turn of the century, terminology of science and technology has been enriched with many metaphorical terms, with natural phenomena comprising the most productive source domain for lexical neologisms. Repurposing of already existing words and expressions (with or without structural modifications) is also common, particularly in environmental sciences. A widespread trend we revealed is the proliferation of multiple metaphorical terms based upon the same word-formation pattern. Thus, in environmental sciences, the metaphorical representation of impact as footprint was originally represented with the term *ecological footprint*, but it eventually gave rise to *carbon footprint, plastic footprint, water footprint* and other, more specialized terms. Moreover, still later the notion of *handprint* emerged as the opposite of *footprint* to denote positive impact of a person or an organization upon the environment. The concept of *black swan* was followed with a whole zoo of other “creatures” that signify events of different probability: *white swan, gray swan, black elephant*, etc. Therefore, it can be argued that even in specialized terminology there is abundant space for linguistic creativity, which primarily relies upon analogical reasoning. Some source domains appear to be so appealing as to be tapped again and again when a modification of the original object or process emerges. In this case, the initial metaphorical representation performs a heuristic function to some extent as it shapes and potentially even constrains the subsequent development of a scientific theory.

It is important to consider that controversy may arise when a metaphorical representation is not accurate enough. *Data pond, Internet of Things, AI hallucinations*, among others, have been criticized in expert communities as not clearly conveying the essence of the process or even misleading non-specialists. We believe that metaphorical terms in science and technology warrant further investigation since they may play important roles in shaping how scientists and researchers conceptualize and communicate complex ideas, uncertainties, and phenomena within their fields.

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