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16. Creative Algorithms and the Construction of Meaning

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Abstract

This paper investigates what we acknowledge as meaningful and new knowledge. It alludes to examples from history, illustrating how human and machine-produced knowledge were often opposed to each other. Taking into account that knowledge is confirmed via a reciprocal process, it argues that by acknowledging and integrating results of machine processes into our daily life, this knowledge becomes "meaningful" also for humans. The acceptance of machine knowledge depends on the cultural network of knowledge confirmation. The strict difference between the two kinds of knowledge, the human and the machine-produced, is vanishing.

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16.1 Appropriating knowledge

Philosophical ontology determines entities and their relations. It defines classes of entities and hierarchies of relations. Intelligent machines rely on such knowledge bases. Algorithms explore them. How do human beings identify what knowledge is? Is this a qualitatively different operation from that of the digital machine? Intelligent machines are also able to supply knowledge, used by both human beings and machines. This procedure can be regarded as similar, since both identify objects and even predict action.

Luciano Floridi viewed questioning the unique prolific and creative manner of human beings a provocation to the humanist self-concept (2014). Moreover, the anthropocentric claim supposes humans to be rational beings. But how do creativity and rationality go together? When Alan Turing investigated the question of whether machines can think, he constructed his famous Turing test, based on the insight that the claim for rationality is relative within a framework of time and culture, and dependent on claims to power. Answering to what he called the *Theological objection:* "Thinking is a function of man's immortal soul. Hence no animal or machine can think," he responds: "I am unable to accept any part of this." To substantiate his doubts, he refers to cultural differences. The arbitrary character of the orthodox view becomes clearer if we consider how it might appear to a member of some other religious community. "How do Christians regard the Moslem view that women have no souls?" he asks (1950, 443). The outstanding attribute of human rational capacity interacted with claims of dominance. It was employed for dominance over women and animals, denying them the capability to think. And it is clear that Turing assumes that this kind of anthropocentric dominance has also been applied to machine-produced thinking.

The most famous philosopher to hold the view that animals and machines are equal in their inability to think was René Descartes (1596-1650). Human beings, animals, and machines differ in their capacity to process knowledge. He compared animals to machines, as he identified "automated" modes of knowledge creation in them both. Not only Turing objected to that view. Many centuries before him, Gottfried Wilhelm Leibniz (1646-1716), philosopher, engineer, inventor of a calculating machine, and strong opponent of various Cartesian ideas, also disagreed with Descartes. Leibniz, as later Turing, denied an ontological gap between animals and people. Leibniz also refused to accept that human beings were created from two different substances, as Descartes had proposed to strengthen his claim that spiritual and corporeal substances were completely different. He objected to the Cartesian idea that only human beings were endowed with intellectual capacities and animals deprived of them, because in Leibniz' philosophical approach a world of complete interconnection was presented. The world was imagined as interconnected by reason. Differences were not substantially well-founded (Leibniz 1923, Mainzer 1994). Leibniz interpreted the world as a rational unity, made up of tiny monads, which he called the most sophisticated "automata". Each monad was a miracle of complexity, reflecting the whole world and all its parts from its own individual perspective. According to Leibniz, there was nothing absolutely "new" and nothing absolutely different, as everything was in relation to each other. Thus, Leibniz began to invent a system to help us to understand and read the world and also to come up with new concepts. Knowledge could be discovered by reducing "composite notions" to a simple alphabet, leading to inventions of every kind when combined according to strict rules (Hecht 1992).

Although Kant owes a lot to Leibniz, his view was beyond any apprehension of the world as a sophisticated automaton. According to him, knowledge was not obtained by the investigation of complex rules to detect the laws governing the world. Instead, he reintroduced the anthropocentric attitude. According to Kant, human creative power exceeds the natural order. It even invents the rules, and nature is obliged to follow. The Kantian creative act of invention was by definition an arbitrary action of "genius". The world was not investigated in order to learn its rules, much more, it was the human genius that gave the rules to the world. Kant defined creative power as an expression of a volitional mind, opposing the idea of constructible and analytically determined knowledge, as is reflected exemplarily in Leibniz.

In the early 19th century, technical engineering advanced and the old ideas were reconsidered. Thus Ada Lovelace, in her famous interpretation of Charles Babbage's *Analytical Engine,* confirmed that this analytical machine was able to process all kinds of knowledge. The *Analytical Engine* was not constrained to automated processes, but able to provide "analytical development," as it iterated and amplified its own knowledge by processing "cycles of cycles" of variables. Although Lovelace's interpretation confirmed that the machine was no longer limited to the reproduction of knowledge, she believed, on the other hand, that the machine could only do "what we know how to order it to do, and thus never does anything really new"(Lovelace 730). According to Turing, we should be careful about what we consider to be new. In his view, the *Lovelace theorem* was open to harsh misunderstandings and subjected "philosophers and mathematicians particularly to a fallacy". It was wrong to give it an interpretation like "there is nothing new under the sun." As a result, Turing tried to provide a "better variant of the objection" and wrote "a machine can never take us by surprise." The problem emerges, he says, from the widespread belief "that as soon as a fact is presented to a mind, all consequences of that fact spring into the mind simultaneously with it!" (Turing 1950, 447). But of course, this is not the case. So the discussion of the "new" is a discussion about the analytical depth of knowledge. Being the master of the principle that rules a procedure does not imply being the master of the procedure itself, and even less, of the outcome of it. Knowing the method does not imply being comprehensively conscious of or mastering all the results that are subsequently produced or provided.

Therefore, Turing investigated thinking and the quest for new knowledge in a different way. He did not regard creativity as an ingenious and spectacular occurrence but argued in favor of a learning process. Differing from Leibniz, he did not claim one type of substance for all "thinking beings". Turing claimed that the substance was even irrelevant to the issue: The human being had no advantage because of her physical and biological difference, being a "continuous machine," as compared to the poor capacities of a "discrete-state machine", as he stated.

The famous Turing test, usually interpreted as a test of machine intelligence, where people are asked to identify whether a human being or a machine is responding to their questions, presents a highly sophisticated scenario. Interestingly, many aspects of this were consequently overlooked by many of its interpreters. Turing creates a situation of everyday knowledge, everyday deceit, and everyday conventional views which is situational for all aspects of human knowledge. He explains a scenario where the interrogator must identify the gender of the agents, who are on the other side of a wall and not perceivable to the interrogator, by means of questions and answers. "The object of the game for the interrogator is to determine which of the other two is the man and which is the woman". The second step is to confront a machine with the problem. It takes the part of the deceiving Agent A in this game: "Will the interrogator be wrong as often when the game is played like this as when the game is played with a man and a woman?" Turing asks (Turing 1950, 433).

Turing hereby proves his insight that knowledge is deeply anchored within culture. It was not a machine's task to "think", whatever that could mean. Turing invented a knowledge-gaining process as a process determined by the cultural habits of acceptance, negation, and knowledge deception. To know and to think are not sole "activities", for example one singular brain activity. Knowledge is determined by a whole cultural network of knowledge confirmation, negation and deception. It is a context-driven process of agreement and rejection.

Turing's sophisticated arrangement of complex facts of common knowledge and the construction of the "test" situation for machines is able to expose illusions of "truth". Knowledge is a complex net of information and the machine's task is to reproduce the kind of behavior which is expected from people. "The reader will have anticipated that I have no very convincing arguments of a positive nature to support my views," Turing states. But it is not Turing's intention to prove an act of “thought” when he speaks about the “thinking capacities” of machines. With regard to his response to the Lovelace argument, he confirms her statement that the rules of operation of the machine are pre-determined. However, “The teacher is ignorant of what is going on inside of the learning machine.” Like children, the machine undergoes a process, arising from a child machine of well-tried design or programing and becomes – as a child does – an agent of full competence. “Most of the programs which we can put into the machine result in doing something we cannot make sense of.” Fallibility and the process-related nature of knowledge are a genuine and necessary part of its development, just as is the case with learning children this is also the case with a learning machine (Turing 1950).

16.2 The paradox of creativity

The rules of the program of a *learning* machine, as Turing called it, are determined, but the outcome undergoes changes during the process. Turing calls this a paradox, as something *new* is produced by a rigid rule and new knowledge can only be gained on the basis of what has already been disclosed. When Turing speaks of the paradoxical idea of the *learning* machine, he emphasizes the fact of the time-invariant rules by means of which during the learning process new rules are created, that are however of a “less pretentious kind” claiming only “an ephemeral validity”. From the rigid rules emerge more flexible ones, the old releases the new (1950, 459).

The paradoxical situation is, however, adaptable to knowledge acquisition as it is processed in human circumstances, whether or not the stable basis of the rule giver to the community and the certain kind of knowledge as being a part of the knowledge community is accepted. What the rules allow is what the community accepts. By accepting “new” knowledge, which, of course, results from the procedures within a community, the community itself enlarges its own knowledge base. Since the new knowledge is actually new, it must be integrated into the corpus of knowledge already at hand, and perhaps to a certain extent it can be considered less valid in comparison to the knowledge corpus that legitimates it. The paradox is that something new can only be defined in dependency on what is already known. This process is similar to that of a *learning* machine. While for the community the new knowledge is defined in dependence to the known, the legitimate base that reigns the *learning* machine is the basic rule. While in the world of humans knowledge is defined as new in relation to the known, for the machine the variations of the *learned* knowledge depend on the rules but the rule interpretation also widens hereby in relevant aspects.

The procedure of acceptance of a creative act and its integration into the knowledge base is a process that works reciprocally. The digital machines driven by today's *learning* algorithms provide us with "new" bits of reality. These machines have provided new segments of reality which become – more or less successfully – integrated into our knowledge world. The knowledge we draw from Google, Siri, and all the algorithms that govern our knowledge is constructed by machines but nonetheless accepted as relevant in the "real" world. The construction of new "meaning" is in full process.

Margaret Boden has investigated the question of whether creative acts can be distinguished from outstanding learning achievements, and she finds that this is not probable. She started an experiment with children to determine the categorical shift that occurs when "new" knowledge is created. Her experiment showed that creative human ideas emerge from transpositions of knowledge into new contexts. She presented conceptual transformations done by 4 to11-year-olds to prove the gradual evolution of the creative process. She characterized this development, starting from an arbitrary multitude of conceptual transpositions provided by the younger children and continuing to the more complex and also more adaptable transformations of the older ones. To be creative, various skills are necessary. The process of learning is, to a certain extent, a process of adaption, transformation and reintegration of concepts within a conceptual space (Boden 1990, 54-88).

Communities are knowledge communities that share a certain kind of knowledge organization and hierarchy. The community identifies itself by what it shares and what it ignores. Therefore, the transposition of any element into another knowledge context can signify a creative invention. The new is dependent on the confirmation process by the already disclosed, hence it is a reciprocal process, where the new is only new if it is accepted by the "old" knowledge.

Examples taken from the history of art and science illustrate this effectively. Picasso used African sculptures as a source of inspiration and he and his art were consequently regarded as brilliant. He delivered a transposition of ideas and for this he gained the attention of those who were important enough to generate acceptance. Others before him, who did the same or similar things, were laughed at and were not successful in becoming a part of the prevailing creative understanding. It is well- known that Picasso performed various kinds of adaptations at the expense of his colleagues. The African sculptures he used were not new, but their powerful transposition into a new context were his creative element. This came at a time when the community was willing to advance and to renew its concept of art. Exceptional knowledge is thus dependent on the response. The most brilliant results are not confirmed as such if their mapping within an "expert" system of their epoch is either not available or unacceptable. Many artists have experienced this, and this is true for many creative people in general, who were often only accepted as innovators many years later or within a different knowledge community. Thus, the paradoxical nature of what is new has been corroborated. To earn the attribute of "new," the knowledge at our disposal is necessary in order to confirm that the new idea is different from what has previously existed. The creative act must be judged as a valuable contribution to established knowledge.

16.3 In defense of creativity

Karl Popper and Hans Reichenbach investigated creative performance, asking how scientific knowledge could be discovered. They believed, in accordance with the Kantian claim, that scientific discoveries were due to an act of creativity which is not rationally approachable. Popper denied that scientific discoveries were approachable by logical means, but he accepted that the explanation and validation of a scientific discovery were done by logical analysis. "There is no such thing as a logical method of having new ideas, or a logical reconstruction of this process," Popper claimed (1959, 33) Hereby, Popper construed a conceptual distinction between the two processes, the process of discovery and the process of corroboration. He established the view of a twofold act, and moreover, of an insuperable difference between these two acts, the one determined as an inventive act, the other as an act of reproductive acceptance. This view was confirmed by Hans Reichenbach. „The act of discovery escapes logical analysis (…) logic is only concerned with the context of justification" (1958, 231). "The transition from data to theory requires creative imagination," confirmed Hempel (1966, 15; 1985). In a clear position against the claims of artificial intelligence, these authors rooted the origins of science and new knowledge in the irrational sphere of the ingenious being. "They agreed that physical laws explain data, but they obscured the initial connection between data and laws" (Hanson 1958, 71). The core ideas can therefore be traced back to the heritage of Kant, who questioned any possible apprenticeship of a new idea in his *Critique of Judgment*. Much more, he countered that the scientific framework itself was created by brilliant arbitrary ideas, instead of being a formative structure of rules by which new ideas could be discovered or generated. Like the mentioned authors, Kant also denied the idea that the function of the rule enabled new insights (Critique of Judgment § 50).

The idea that scientific knowledge is due to uncontrollable interactions is also claimed by Thomas Kuhn. Kuhn differs from the above mentioned, as he insists on the reciprocal dependency of scientific inventions and their historic backgrounds.

He confirmed the requisite intertwining of a scientific theory and the knowledge community from which it arose. But instead of investigating the structure of these interdependencies in order to understand what supports the acceptance of a scientific innovation, like Popper, Reichenbach and many others, he idealized the act of new ideas emphatically as "imaginative posits, invented in one piece" (1970).

It is not by chance that artificial intelligence researchers have positioned themselves as epistemological alternatives to these theorists. Herbert A. Simon, Alan Newell and others working in the field of artificial intelligence reject the view that scientific discoveries can be triggered by irrational or random events. They emphasize that scientific findings are bound to the context from which they emerge. The discovery, if it can be assessed as such, is bound to the context which allows the validation of what is new. Strengthened by this insight, they have constructed their theories on the basis of the necessary and reciprocal relationship between scientific discovery and the background knowledge from which it arose. Their well-defined heuristic procedures were finally able to reconstruct specific scientific discoveries. The BACON One program successfully "discovered" Boyle's law among others. This program was based on simple algorithmic instructions. First: "Look for variables (or combinations of variables) with a constant value". Second: "Look for linear relations among variables." Third: "If two variables increase simultaneously, consider their ratio." Fourth: "If one variable increases while another decreases, consider their product" (Langley, Simon, Bradshaw and Zytkow 1987).

Laws of Galileo and Kepler were reconstructed. The program *Automated Mathematician* successfully employed an algorithm to demonstrate the generation of primes according to De Morgan's law and to prove Goldbach's Conjecture (Hayes 1989, Simon 1977). This "ingenious" outcome was discovered within the framework of rules, logically driven by heuristic procedures and a selection of data. The objections to the findings of BACON clashed with this procedure. The critics objected that the "invention" was not "new", but strategically prepared, as it was processed according to strict rules within a certain amount of data. But the critics of the automated procedure have overlooked exactly this intention: There was no difference in the act of discovery and validation. Based on these insights, Newell, Shaw and Simon came closer to how "creative" thinking might be explained (Newell, Shaw, Simon 1967). Researchers at Brunel University developed the *WISARD pattern recognition machine,* which succeeded in including and processing unknown patterns. A further strategy, allowing the weighting of the elements in the process, refined the results, as hereby elements of the pattern could be more easily selected (Mainzer, Balke 2005).

Today, heuristic procedures have increased and even dominate in the knowledge we gain of the world we live in. "Algorithms are little more than a series of step-by-step instructions ... however … their inner workings and impact on our lives are anything but," stated Dormehl, asserting that algorithms solve all our problems but also create many more (2014). Self-adapting and self-constructing programs generate "new" knowledge based on a wide variety of data bases and according to rules. Today a huge and unmanageable data volume has become manageable via algorithms, which organize „packets", using parallel processing computers and achieving tremendous results. They are "so to say … able to identify the needle in a haystack" (Mainzer 2014).

These machines sketch our cars and our houses, our way to the moon and beyond. Through their data collection and processing, they are able to define health and illness. They operate in the human body or in the earth's crust. We accept Siri's answers as often more reliable than the answer from some human being we have asked for directions. Our community life is shaped according to the social networks invented in the digital world. All this intelligence has become part of our knowledge community. It provides us with "new" insights and "new" objects. All this deserves to be meaningful, in the case that we accept its "ideas" as answers to our questions. We construct the "meaning" of our lives when we accept what is proposed to us by the intelligent machines. We act with machines, we reflect on the knowledge provided by them and together with it. We have become one intellectual community. The concepts provided by our digital machines provide a stable part of our world interpretation. We live in a world which is, to a great extent, still structured by artificial concepts, which we are free to accept and give "meaning" to.

What is commonly called creative thinking is actually a selective procedure, accomplished by delving through a multitude of data, according to an inner working of the algorithms that widely shape the knowledge of today (Hagengruber 2005). Learning algorithms affect our lives in many ways: how we think, whom we know, what we know. Our knowledge is still part of the artificially provided knowledge: The feedback loops between human knowledge and machine-produced knowledge are constitutive for what is "meaningful" to us. The knowledge bases have mixed and the knowledge procedures enhance each other reciprocally. The knowledge provided by means of technology reflects on our own, and vice versa. This is true with regard to the knowledge we discover, as it is true of the knowledge we validate. The knowledge community is no longer only constrained to human beings. We share our world of meaningful entities with our digital machines.

References

Boden, M. A. 1990. *The Creative Mind. Myths and Mechanisms*. London: Routledge.

Dormehl, L. 2014. The Formula. How Algorthms solve all our problems and create more. London: Virgin Books.

Floridi, L. 2014. The Fourth Revolution in our Self-Understanding. Ruth Hagengruber and Uwe Riss (Eds.) *Philosophy, Computing and Information Science*. London: Pickering and Chatto, 19-29.

Hagengruber, R.. 2005. Mapping the Multitude. Categories in a Process Ontology. In *Professional Knowledge Management Experiences and Visions*. 3rd Conference WM 2005. Berlin u.a.: Springer.

Hagengruber, Ruth and Riss, Uwe (Eds.) 2014. *Philosophy, Computing and Information Science*. London: Pickering and Chatto

Hanson, N. R. 1958. *Patterns of Discovery*. Cambridge: Cambridge University Press.

Hayes, J. R. 1989. Cognitive Processes in Creativity, In *Handbook of Creativity*, hrsg. J. A. Glover, R. R. Ronning und C. R. Reynolds, 135-145. New York: Springer.

Hecht, H. 1992. *Gottfried Wilhelm Leibniz. Mathematik und Naturwissenschaften im Paradigma der Metaphysik*. Stuttgart-Leipzig: B.G. Teubner.

Hempel, C. G. 1966. *Philosophy of Natural Science*. New Jersey: Engelwood Cliffs.

Hempel, C. G. 1985. Thoughts on the Limitations of Discovery by Computer. In *Logic of Discovery and Diagnosis in Medicine,* hrsg. K. F. Schaffner, 115-122. Berkeley: University of California Press.

Kuhn, Th. S. 1970. Logic of Discovery or Psychology of Research. In *Criticism and the Growth of Knowledge,* I. Lakatos und A. Musgrave, 1-23. Cambridge: Cambridge University Press.

Langley, P., Simon, H.A., Bradshaw G.L. und Zytkow J.M. 1987. *Scientific Discovery: An Account of the Creative Processes*. Cambridge, Massachusetts: MIT Press.

Leibniz, G. W. 1923-. *Sämtliche Schriften und Briefe*. Hg. v. der Deutschen Akademie der Wissenschaften zu Berlin, Berlin: Akademie-Verlag, II, 1, 160.

Lovelace, A. 1843. Sketch of the analytical engine; with notes from the translator Ada Lovelace. in: Taylor, R.: *Scientific Memoires* Vol. 3. Selected from the Transactions of Foreign Academies of Science and Learned Societies and from Foreign Journals. London: Richard and John E Taylor.

Mainzer, Klaus. 1994. *Computer – Neue Flügel des Geistes? Die Evolution computergestützter Technik, Wissenschaft, Kultur und Philosophie*. Berlin u.a.: De Gruyter.

Mainzer, Klaus. 2014. *Die Berechnung der Welt. Von der Weltformel zu Big Data*. München: C.H.Beck.

Mainzer, K., Balke, W.-T. 2005. Knowledge Representation and the Embodied Mind: Towards A Philospohy and Technology of Personalized Informatics. In *Professional Knowledge Management Experiences and Visions*. 3rd Conference WM 2005, hrsg. C.D. Althoff, A. Dengel, R. Bergmann, M. Nick und T. Roth Berghofer, 586-597. Berlin u.a.: Springer.

Newell, A. Shaw, J.C. und Simon, H.A. 1967.The Process of Creative Thinking. In *Contemporary Approaches to Creative Thinking*, hrsg. H. E. Grubner, G. Terell, M. Wertheimer, 63-119. New York: Atherton.

Popper, K. R. 1959. *The Logic of Scientific Discovery*. London: Hutchinson.

Reichenbach, H. 1958. *The Rise of Scientific Philosphy*. Berkeley: University of California Press.

Simon, H. A. 1977. *Models of Discovery*. Dordrecht: D. Reidel.

Turing, A.M. 1950. Computing Machinery and Intelligence. *Mind* 49: 433-460