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Invention and Metamorphosis
Intelligence, Automated Optimization (AO) and the Prospect of Synthetic Intelligence with Simondon and Denizhan

Cécile Malaspina

Abstract. *Within the wider arc of Gilbert Simondon's philosophy, invention stands out as a stage in the development of mental images, rather than a faculty distinct from perception and memory. Of particular interest is a phase of transition that precedes invention in the development of mental images. Simondon compares this transition to the process of metamorphosis occurring in some species. This transition in the development of mental images is marked by the dedifferentiation of the dominant organizing principle. This dedifferentiation paves the way for the possible reorganization of mental images at a higher level of development. The free play of mental images corresponds to this transition, enabling the discovery of a new organizing principle with unprecedented possibilities of adaptation. It is enlightening for contemporary debates about machine learning processes, like those operative in Large Language Models or of image generation, to think carefully about this transition. In this article, we will look at the significance of this transitional dedifferentiation in living beings. This will lead us to argue against the use of the term Artificial Intelligence. A better alternative seems to be the term 'Automated Optimization' (AO) – suggested by the engineer and philosopher Yagmur Denizhan. Denizhan defines intelligence as the «border activity between the modelled and the unmodelled», i.e. between what is admissible in our model of reality and what is excluded or not yet encompassed by it. Intelligence thus conceived, I propose, is directly relevant to Simondon's analogy between invention and metamorphosis. The «border activity» between the modelled and the unmodelled, at the level of cognition, may thus correspond to free play of mental images in the strong sense, namely, as involving transitional dissolution of their organising principle. Without it, I argue, we cannot begin to understand the historical recasting of our mental worlds, including paradigm shifts in the arts, science and technology.*

Keywords. Simondon, invention, imagination, Artificial Intelligence (AI), Large Language Models (LLM).

Cécile Malaspina is the author of *An Epistemology of Noise* (Bloomsbury, 2018) and principal translator of Gilbert Simondon's *On the Mode of Existence of Technical Objects* (University of Minnesota Press, 2017). She is *directrice de programme* at the Collège International de Philosophie, Paris (Ciph) and Visiting Research Fellow at King's College London and the University of the West of England, where her program for the Ciph is hosted by the Departments of French and Philosophy respectively. She is contributing editor for *Angelaki: Journal of the Theoretical Humanities*; commissioning editor for the independent publisher Copy Press; and guest editor at *Nature: Humanities and Social Sciences Communications*.
Email: cecile.malaspina@gmail.com

The metamorphosis of species like butterflies highlights key transitions in development. What is remarkable about the transitional morphological dissolution and dedifferentiation, paving the way for metamorphosis of the larva into the butterfly or sea urchin, is that something becomes explicit and visible to the eye, remaining implicit in other examples of ontogenesis. Yet it is no less critical, even if more implicit, say, in the development of the human child or in the historical transformations of societies. This transition is particularly relevant to our understanding of the distinguishing hallmark of human intelligence, namely, the role of the imagination. There is an analogy, Simondon argues, between metamorphosis and the development of mental images, paving the way for invention. What they have in common is not a structural similarity, but an operational analogy: in both instances, the living being is jettisoning a hitherto dominant principle of morphological, physiological or other organization in order to bring about a new organizing principle. This is one of the many startling lessons students of Gilbert Simondon will have learned from his 1965-1966 lecture series at the Institute of Psychology in Paris. The lectures were published posthumously as *Imagination and Invention* and translated into English as recently as 2022 (Simondon 2022; 2008).

Simondon's analogy enables us to question today's labelling of Machine Learning processes as intelligent. Are they capable of jettisoning the model that acts as their organizing principle, and of recasting it in an entirely new form? The answer, at the time of writing, is no. Intelligence in living beings, I will argue, is derived from the capacity to reorganize and transcend pre-existing principles – a capacity absent in predictive processing algorithms. Today's analogy between human and artificial intelligence designates as intelligent a machine or algorithm whose output is human-like. Algorithms would thus become more intelligent as their output becomes more human-like. The analogy, however, is misleading to the extent that it is based on morphological similarity rather than analogy of operation.

In what follows, I will expand on and contextualise Simondon's analogy between metamorphosis and invention within the arc of his theory of individuation and with reference to Yagmur Denizhan's argument in «Intelligence as a border activity between the modelled and the unmodelled» (Denizhan 2023).

1. Metamorphosis and the free-play of mental images in the context of individuation

The purpose of this contribution is to foreground the contemporary relevance of Simondon's analogy between metamorphosis in some species and the process of invention occurring in other animal species, including and especially humans. Situating the invention within the wider arc of Simondon's theory of individuation, we will draw into focus the development of mental images as a process of individuation. Of particular interest is Simondon's attention to the transitional phase that implies a dedifferentiation of the hitherto dominant principle of organization, preceding a significant reorganization at a higher level, affording novel adaptations. This transition is the basis for Simondon's analogy between invention and metamorphosis, as between two processes with operational equivalence. It is not a false analogy between two structurally or otherwise similar phenomena. The contrast intended here is between the operational analogy of critical transitions in otherwise different beings – the larva's morphological metamorphosis and the recasting of an organizing principle in the act of invention – *versus* the false analogy, based on similarity, for instance between texts produced by humans and the human-like output of Large Language Models (LLMs).

The term individuation is too frequently treated as synonymous with ontogenesis. Before indicating some peculiarities of the concept of individuation, let me sketch out the broad outlines of ontogenesis. The term ontogenesis refers, in part, to a term coined by the 19th century biologist Ernst Haeckel to posit the development of the organism (also ontogeny), from fertilization to maturity, as a recapitulation of the species' evolution (phylogeny). For Simondon, on the other hand, an account of "veritable" ontogenesis must encompass the genesis and becoming not only of the individual or the species but of the system within which individual and milieu co-emerge and co-evolve (Simondon 2020a, 3).[1] The individual

[1] For a contemporary philosophical rehabilitation of context, see Juarrero (2023).

is only a partial result of this veritable ontogenesis. In a more speculative sense, ontogenesis hails from the Pre-Socratic conception of the productive dynamism of *physis*, the becoming of nature and continual and reciprocal transformation of elements. (Simondon 2020a, 364-365).

While he does define ontogenesis as a process of individuation, he also specifies that not all processes of individuation result in ontogenesis. Not all processes of individuation bring about a fully individualized entity that remains topologically fully distinct from its milieu. Individuation may also refer to a process of continuous variation of form, as for instance the continuous modulation of a radio signal or the swirls in a river. Individuation designates the processual genesis (within preindividual being or, more narrowly, within an existing system that is not fully determined) of an entity or process whose uniqueness is individual in the sense of its singular *thisness* in the *here and now*.

Individuation weights the attention towards the *individuating individual*, while ontogenesis draws our attention to the genesis of the *individuated individual* as an entity distinct from the milieu. Spinoza's distinction between *natura naturans* and *natura naturata* may be helpful to render this difference more intelligible. The *individuating individual* may be a continuous variation of form, in mid-flight, not necessarily resulting in an *individuated individual.* The *individuated individual,* on the other hand, would be this partial result of ontogenesis properly conceived, that is, the by-product of the becoming of being in the most generic sense, and more particularly the by-product of the genesis of a system wherein the distinction between individual and milieu arises.

In *Imagination and Invention*, Simondon uses the term metamorphosis to refer rather more straightforwardly to a stage in the development of an organism. While the metamorphosis of the larva results in the ontogenesis of the butterfly, it is worth keeping in mind here the implicit idea that the development of mental images may involve more open processes of individuation, as variation of form. With these nuances in mind, let us turn towards *Imagination and Invention*. Here Simondon refers to the organism as host to a plurality of secondary individuations happening concurrently, but not in perfect synchronicity. The maturation of different physiological systems occurs at an uneven pace. In this polyrhythmic development occur transitional dedifferentiations and reorganisations:

> Studies of ontogenesis have shown that growth processes do not cover the organs and functional systems of a living being in a uniform way: there are lags in each partial growth relative to the others, and there are different speeds, especially among complex organisms, so much so that it is difficult to establish the exact moment at which an organism reaches its complete adult stage; moreover, growth and development display stages and cycles, separated by periods of transition in which a dedifferentiation is followed by a reorganisation. Such processes are very clear in the metamorphoses of some living species, yet they also take place in the organic development and the ontogenesis of human behavior. (Simondon 2022, 18).

Ontogenesis, then, is composed of a plurality of layered and nested secondary individuations, whose development is complex and polyrhythmic, punctuated by transitional dedifferentiations, as in metamorphosis and in the free play of mental images. Simondon defines the development of mental images as a secondary individuation constituting a structural and functional subset of psychic activity, which is itself a secondary process of individuation within the organism. «Could we not then posit that mental images are like structural and functional subsets of this organized activity that is psychic activity? These subsets would thus possess a genetic dynamism analogous to that of an organ or a system of organs on a trajectory of growth […]». (Simondon 2022, 18).

Mental images, as structural and functional subsets of the psyche's organized activity, thus possess a genetic dynamism of their own with an intrinsic growth and development analogous to that organ. Like the genesis of organs, the genesis of mental images obeys developmental stages: from the embryonic stage of spontaneous growth to becoming a source of pre-adapted response schemas in anticipation of stimuli from the milieu, and from their increasingly functional role in movement and perception, mental images finally organize themselves in a veritable “mental world” with its own constraints and topology. This last stage, crucially, results not in a mirror image of the experienced milieu, not in a representation of an *extra mental* reality.

> […] first, that of pure and spontaneous growth, prior to the experience of the object to which a functional activity is pre-adapted; this would be, in the image, the equivalent to the embryonic stages of organic growth; each image, as an embryo of motor and perceptual activity, develops itself for itself here as a non-controlled anticipation, through reference to the experience of the milieu, and to a free state, which is to say without strict correlation to other subsets of psychic activity. It displays pre-adaptations but not adaptations. The image then becomes a mode of receiving (*accueil*) information coming from the milieu and a source of response schemas to these stimuli; in perceptual-motor experience, images become effectively and directly functional; they organize and stabilize themselves in internally correlated groups according to the dimensions of the relationship between the organism and the milieu. Finally, after this stage of interaction with the milieu corresponding to a learning process (*un apprentissage*), an affective-emotional repercussion completes the organization of images according to a systematic mode of linkages, evocations, and communications; a veritable mental world is constituted, with regions, domains, qualitative key points through which the subject commands *an analog of the external milieu*, one that has its own constraints, its own topology, its complex modalities of access. (Simondon 2022, 18-19, emphasis in the original).

Mental images are not mere aggregates of sensory data. They are not a reflection, or mimetic representation but obey an operating principle analogous to that of the experienced milieu. Perception thus finds its place in the organized activity of the psyche and within it, in the organized development of mental images. From one developmental stage to another, mental images progress towards greater integration, more tightly organized systematic interdependences and towards a saturation of inter-linkages. The interdependencies between mental images are increasingly tight-knit as experience of the environment progressively specifies these linkages, and generates an entirely new set of affordances: the basic adaptations having been accomplished, a window of opportunity opens up for a free play of mental images, but at a higher level of adaptation.

> In other words, images would undergo successive mutations that would modify their mutual relations by making them pass from the status of primitive mutual independence to a phase of interdependence at the moment the object is encountered, to a final state of systematic and necessitating linkage in which primitively kinetic energies have become tensions within a system. Invention could then be considered as a *shift in the organization* of the system of adult images, returning mental activity to a new state of free images, through a change of level, thus allowing a genesis to start again: invention would be the rebirth of the cycle of images, one that permits an approach to the milieu with new anticipations from which adaptations will emerge that were not possible for primitive anticipations, and then a new internal and symbolic systematization. In other words, invention operates a change of level; it marks the end of a cycle and the beginning of another, each comprising three phases: anticipation, experience, and systematization. (Simondon 2022, 19, emphasis in the original).

The mental is thus an active constructive organization of possible experience forming a system for the reception of signals and information coming from the milieu, and a source of schemata for responding to stimuli. The saturation or maturation of this system paves the way for its possible metamorphosis through the free play of mental images.

We already encounter the idea of dedifferentiation in *Form, Information, and Potential*, a conference paper presented before the Société Française de Philosophie in 1960

(Simondon 2020b, 672-697). In this text, Simondon cites the American psychologist and paediatrician Arnold Gesell, who first proposed that all children go through a set of concurrent developmental stages, in a sequence largely influenced by the maturation of their nervous system. Gesell's observation concerning embryology, growth and behavioural development, foregrounds the apparent dedifferentiation of already acquired adaptive adjustments during periods of transitions between stages, entailing crises of self-regulative fluctuations and periods of relative disadaptation. The infant, for instance, develops a first pattern of waking at night, but suddenly «wakes at any moment whatsoever and seeks nourishment when it cries». Then, «all of a sudden, it *restructures* its activity», but based on fewer meals per day: «The schema is clear […] the disadaptations mark a moment in the search for a new structure» (Simondon 2020b, 690-691). The initially acquired "patterns", i.e. the initial adaptation, seem lost, but, in fact, they are reincorporated into the new adaptation. The process of maturation as a whole generates new *tendencies,* new adaptations, but also new demands.

The analogy with metamorphosis in *Imagination and Invention* finds a wider context in this text, which Simondon concludes with reference to Carl Jung's theory of individuation, couched in the language of alchemy. The crisis of dedifferentiation is defined by the notion of *Liquefactio* (dissolution) and even *Nigrefactio* (putrefaction). In this crisis, «substances lose their limit and their individuality, their isolation», paving the way for a new differentiation, the «*Cauda pavonis* or peacock's tail», where objects emerge «from the confused night». Jung considered dedifferentiation to constitute a necessary sacrifice, enabling the return to a state «comparable to that of birth» (Simondon 2020b, 696-697).

The process of dedifferentiation, Simondon argues, serves to reconstitute the systems of potentials, i.e. it signals the return to «a richly potentialized, not-yet-determined state». The «somewhat liquidated elementary schemas» correspond, within Simondon's greater arc of individuation, to an increased metastability, a greater susceptibility for sudden change or structuration around a novel principle of organization. Metastability, like a basketball spinning on our finger, is a fragile state of equilibrium that is prone to transformation. This metastability provides the potential for transformation, contained in the tension between disparate aspects of reality. While thermodynamic potential is a theme that is paramount, Simondon extends his concept of «disparation» to any disparity that can act as a tension. A very different example would be the binocular disparity between the left and right eye, whose resolution leads to the perception of depth. The metastability that this tension fuels constitutes what Simondon calls a «first information». This must not be misconstrued as a primordial source of information but should be understood as a condition of possibility of individuation. This first information or condition of possibility is draw, in the largest sense possible, from what Simondon defines, in Ionian fashion, as the *apeiron,* the unbounded and indeterminate, from which Anaximander makes every individuated form emerge: «[T]he Ionian physiologists found in nature the origin of all types of being prior to individuation; nature […] his ἄπειρον [*ápeiron*] […] would remain in the individual, like a crystal that retains its mother liquor, and this charge of ἄπειρον would allow it to go toward a second individuation» (Simondon 2020a, 343).

Whatever triggers the transformation of a preindividual metastable state acts as information broadly conceived. It may occur in the manner of an event, of an entity, like the grain of dust in the pre-crystalline solution, or as a threshold of intensity that is crossed, for instance when the tension in the atmosphere is discharged in the transitory individuation of a lightning bolt. Information is this singularity or event that brings about a tipping point, that provokes a bifurcation or phase transition in the system. It is defined by its singularity in the here and now, its *haecceity* or thisness, and by the affinity of this haecceity with the given potentials. A grain of sand may trigger the crystallisation of an oversaturated solution, but be of no such consequence on a sandy beach.

Information is the *tension of form*. It corresponds to the metastability of a system, to its potential transformation, together with whatever entity or event is singularly suitable to trigger individuation, to trigger the ontogenesis properly conceived, that is, the ontogenesis of a system, giving rise to the individual form, its milieu, and the dynamic relation between. Information is thus the encounter of this condition of tension with an event or entity capable of catalyzing transformation. I insist on this point, in view of our discussion of so-called Artificial Intelligence: ontogenesis, *veritable* ontogenesis, is not the emergence of an entity, not only, it is the emergence of a system where there was none. The event or entity that catalyzes the process of individuation mediates the tension between hitherto disparate aspects of reality. This mediation, via the nascent individual, establishes the communication between hitherto independent aspects of reality and thereby brings about a system where there was none (or a novel system within an existing system). Information, in Simondon's sense, is never a given, a *datum.* Information must satisfy the three conditions of first information (disparity, tension, potential; metastability), a catalyzer (affinity of an entity or event with the given tension) and the emergence of a system wherein hitherto independent disparate aspects of reality communicate: emergence of a phase, of chrono-topology distinguishing inside and outside, before and after, individual and milieu.

Information, thus conceived, cannot be conflated with the data that is fed into programmes like LLMs. To inquire into the intelligence of algorithms, within Simondon's framework of individuation, requires a careful transposition of the criteria of individuation onto the matter of man-made machines that operate, with margins of indeterminacy, within existing systems. The transitional dedifferentiation in metamorphosis, in the infant's development and in the free play of images, is but the living being's singular capacity to regenerate its tension of form. In what way can we speak of information, of tension of form and of the capacity to regenerate tension of form in relation to an algorithm that is, essentially, a programmed, predefined rule with a finite margin of play?

2. Intelligence as a Border Activity Between the Modelled and the Unmodelled

To what extent, if at all, might one imagine an organism as dissolving its organizing principle, its own code, in such a manner that another novel principle of organization may emerge, one affording a novel and greater adaptive functionality? To what extent this is true for our genome, our proteome, our hormones and neurotransmitters, our reflexes and earliest imprints, for the *mille-feuille* layers of our physiological, psychological and sociocultural principles of organization? From evolution to contemporary culture, every layer of this complex individuation testifies to degrees of freedom, at different time scales, in reloading the tension of form. The tension of form, for the living being, indelibly links its multidimensional and polyrhythmic individuations to the wider ontogenesis of a system formed by the genesis and co-evolution of individual and milieu.

Can an algorithm compare with the organism's multidimensional, polyrhythmic and open-ended complexity of organization? How might one define an algorithm's resilience to a transitory dedifferentiation and ensuing disadaptation? Is it at all possible to extend Simondon's analogy between metamorphosis and the free play of mental images to the models of reality that are programmed into the algorithms that power machine learning?

Yagmur Denizhan – Professor in Chaos control, Modelling of nonlinear dynamic systems at Boğaziçi University in Istanbul and a bio-semiotician – distinguishes between the capacity of living beings to expand their model of reality and the predefined, model-based operations of machines (Denizhan 2023). In computer science, the model is a mathematical or computational representation of a predefined system on which the algorithm will be based. The model is a simplified representation of a complex system. It encapsulates features essential for specific tasks, enabling prediction, understanding, or control, be it as the basis of software applications for users or be embedded in robotic systems, for instance of a robotic arm adjusting its grip. The architecture of the model may be that of a linear regression, for instance, predicting continuous output. A decision tree, on the other hand, enables the classification and regression of tasks. The architecture of a model may be convolutional, as in neural networks for image recognition, or recurrent, dealing with time-series and sequential data etc. In all instances, the model selects and defines key parameters in accordance with the objective to simulate a specific aspect of reality, while ignoring other parameters. Based on this model, the algorithm is a set of rules, using symbols or logic, for the execution of specific tasks, for instance to process data in order to make predictions or decisions.

To date machines operate within the fixed, predefined models. These models are typically designed to be capable of adapting to changing inputs. However, Denizhan points out, this adaptation is limited to finite, set parameters. The machine cannot expand the scope of these parameters beyond their original design. In other words, technological systems, to date, use models with fixed ontologies, with a finite ability to adapt beyond what has been programmed. While so-called artificially intelligent models can adjust certain parameters, they cannot undergo significant change without external intervention. In other words, while some parameters are free to accommodate feedback, this freedom has little to do with the philosophical considerations of freedom as self-determination or *libre arbitre* that have animated millennia of debates in ethics, political theory, theology or, for that matter, ethology. In contrast, cognitive models in humans are dynamic, evolving structures that can grow or reorganize through interaction with others and the environment.

Human cognition, of course, generates models of reality and not only those for computer science. Our models of reality form part of an evolving knowledge structure, which Denizhan refers to as the «Edifice of Knowing». The most recent additions may adapt more fluidly, accommodating new experiences and expanding the individual's understanding of the world, while older strata, like reflexes, are more inflexible. Denizhan categorizes cognition into two distinct modes: mode "A" represents routine, predictable operations that rely on fixed knowledge models. Mode "B", on the other hand, involves higher level cognition involving creativity, uncertainty, and new ontological categories. Mode B engages with uncharted, as yet unmodelled aspects of reality. Mode B is not merely about processing what occurs within predefined parameters for information, but about restructuring and expanding the model of reality creatively.

This level of problem solving requires the transformation of the operative model of reality to expand into the unmodelled. The unmodelled is not a space or unchartered territory beyond some imagined topographical boundary of the explored. It represents rather the unknown aspects of reality, the aspects that are not included in a system's model of reality or cognitive framework. The unmodelled refers to dimensions of reality that the current model cannot grasp and, crucially, does not know it cannot grasp until confronted with problems that require intelligence to tackle the boundary of the model and the unmodelled.

The modelled and the unmodelled interact dynamically. New information can reshape the current model, incorporating previously unknown elements. Denizhan defines this as the capacity for «ontological expansion». By this account, engaging with the unmodelled is a hallmark of higher-level thinking, such as creativity and innovation. Denizhan posits this as a criterion for the distinction between the intelligence of living beings and the processes of «automated optimization» (A.O.) that characterise what is commonly called Artificial Intelligence (A.I.).

In a forthcoming paper entitled *Synthetic Mutations, Mistakes, and Glitches* (Lu, forthcoming) computer scientist and philosopher Christina Lu has, independently from

Denizhan, proposed the notion of «ontological stasis» to define the limitations of Machine Learning models, which remain fixed once trained, and unable to adapt to unforeseen changes, notably those occurring in society. Current Machine Learning systems, she argues, also suffer from training isolation: models are trained in isolation, reinforcing initial biases and preventing adaptation to new data. They also suffer from what she calls «Error Eradication». By eliminating errors, Lu argues, the programmers deprive models of the creative discoveries and evolution fuelled by mistakes.

Lu looks towards biological evolution to speculate about future «synthetic evolution» through the deliberate introduction of mutations and mistakes in AI models, which may eventually allow them to evolve and adapt dynamically. This speculative perspective may indeed open a horizon in which the ontological stasis may give way to an «ontological dynamism» of co-evolution of models and their environments, by incorporating «unknown unknowns».

Are recent developments, from Generative A.I. to Meta-Learning and Evolutionary Algorithms satisfy the criterion of ontological expansion? They certainly show how abundant the margin of play of the algorithm's free parameters is.

Generative Adversarial Networks (GANs) and Large Language Models (LLMs) like ChatGPT-4 discover patterns in complex distributions of enormous amounts of existing data publicly available on the internet, using "billions of parameters". Recurrence in words, sentences, and sequences enables them to statistical chunks with predictability, yielding patterns on the basis of which the LLM can predict what might come next. Sonia de Jager has shown, with the example of Winograd schemas, how susceptible LLMs are to encoding bias when dealing with ambiguity in language, in contradistinction to the way languages and cultures evolve on the basis of ambiguity (de Jager 2023).

There are generative adversarial networks (GANs) that pit two models against one another: the model generating output tries to "fool" the model that learns to discriminate "real" data from generated data, thus continually improving both. Or diffusion models, used in text-to-image generation, iteratively refine output that resembles samples in the training dataset. Transformer architecture models, in turn, encode words in a corpus of text as a "token" for an "attention map" enabling the model to work with context (Zewe 2023). Leveraging extremely large, high-dimensional and complex search spaces, using "population-based" search techniques allow more recent developments in evolutionary computation not only to model and restitute versions of existing data, but to propose solutions to problems (Miikkulainen 2021). Evolutionary computation is perhaps the closest to Lu's wish for ontological dynamism. Extremely large, high-dimensional and complex search spaces, requiring substantial computational resources, are leveraged to evaluate large populations of candidate solutions to a problem. The population of candidate solutions evolves over successive generations, starting with a random iteration of candidate solutions, followed by iterative evaluations using operators like crossover (combining parts of two solutions) and mutation (introducing random changes).

While this method is prolific at generating potential solutions to a given problem, we may still ask whether these algorithms, as formidable as progress in this area is, have the remit of something like a metamorphosis or critical transition involving dedifferentiation of the model in view of a potentiated tension of form and the generation of an entirely new model at a higher level of adaptation. Can evolutionary computation be designed in a manner that allows the algorithms to expand from the modelled into the unmodelled?

The simpler question that seems worth asking is whether, in this evolutionary adaptation of solutions to a predefined fitness function, also the programmed fitness function can be revised without human input. The history of political ideological appropriations of Darwin's theory of evolution, notably in the domain of statistics and eugenics, should sound a warning about how badly things can go with an ill-conceived concept of fitness. Can an algorithm designed to solve a given problem become an algorithm that identifies hitherto unknown problems or even inventing new problems, as philosophers, mathematicians, scientists, inventors and artists have done for millennia? Is computational computation designed to expand, eventually, from the given, the data set, into the truly virtual? By virtual I do not mean the representations and simulations animating user interfaces, nor the myriads of digital processing operations invisible to the user, but the domain of the possible which cannot be confined to the actual, to what is given and can be converted into data.

The open-ended expansion into the field of possible experience is characteristic of both biological evolution and socio-cultural historicity. In Simondonian terms this openness resides in the ἄπειρον (*ápeiron*), the unbounded and indeterminate state of being which is the condition of possibility of individuation. What might be its analogon with respect to the data sets upon which the algorithm exercises its predetermined tasks or fitness functions? This entails the question concerning the conditions of possibility of experience *per se* and of the experience of novelty, which is to a certain extent the same. In metamorphosis and invention, what is at stake is the alteration of the conditions of possible experience, of what can become a datum of experience, and also of what counts as a possible datum of experience or is discounted as noise. How does this criterion change the question regarding intelligence and learning, the use of models of and schematizations of reality and their limits in living beings and in human made machines?

Conclusion

To what extent is the analogy between intelligent cognition in living beings and the «automated optimization» of machines warranted? I propose that the analogy is not unhelpful if we compare how algorithms operate to what Denizhan defines as mode "A", i.e. in predictable, routine operations relying, respectively, on fixed knowledge models. In a number of respects, digital technology has already outpaced the cognition of living beings in mode "A". The processing speed of digital processes, measured in gigahertz or billions of cycles per second, far outpaces the 80-120 meters per second (m/s) action potentials of some neurons. Parallel processing of tasks, scope of data analysis, memory storage and recall, as well as image recognition and natural language processing are domains in which the automated optimization of these processing tasks outperforms a human individual. Complex models, like climate or multidimensional datasets about the economy (e.g., genomics, financial markets), can be processed almost instantaneously and indefinitely by machines (energy supply permitting). An algorithm may process medical records and perhaps even communicate with patients to their greater satisfaction than a human doctor. It can translate most texts satisfactorily across dozens of or identify financial market trends and execute transactions in microseconds, without factoring in human limitations due to fatigue, cognitive overload, physiological or psychological conditions.

It may seem appropriate to speak of artificial intelligence with respect to the automated optimization of processes analogous to mode "A", and in narrowly defined tasks, where digital technologies outpace the human in brute-force computation. However, Denizhan singles out a weakness in the analogy: the human chess player deploys a creativity that adapts to the means at its disposal. Creativity enables the truly intelligent being to leap over the computation steps. What characterizes human intelligence and creativity within relative scarcity of resources, when compared with the computational power, memory and speed of the machine. While the output may be similar, to a certain extent, the operational logic and the principle of organization are different.

However, algorithmic automated optimization may inform our conception of intelligence differently than commonly assumed. Rather than boxing intelligence into the framework of sophisticated automatisms by comparing their intelligence, these technologies do oblige us to reconsider the legacy of historical approaches to development, education, and work. If these have traditionally exalted the sophistication of cognition in mode "A" of cognition, doing so at the expense of genuine intelligence, then we may now need to bring about a transition towards a culture in which development, education, and work value and foster, rather than stultify, neglect, and squander, intelligence in mode "B".

Metamorphosis and invention are problems of individuation. One could also say they are about the individuation of a new problem. The question whether metamorphosis and invention are the expression of intelligence is speculative and implicit, if we consider metamorphosis as the fruit of evolution and phylogenesis. It is explicit, yet not less speculative, if we consider the problem-solving of intelligence of living individuals, be they singular or collective. From the formidable complexity of the unicellular organism to the cultural complexity of humans, including but not limited to *techne* in the arts and technology, problems of vital importance are not only solved, but new problems are individuated: not only those that are accidentally brought about as an unintended consequence of solving another, but also those that are disclosed, if not invented as horizons for future individuation. The invention of a problem is ultimately, like metamorphosis, about the potentiation of a living being's tension of form. Herein lies, essentially, the difference between the execution of a task and its problematization.

The nature of the problem must be thought in the context of the ultimate problem, namely that of a veritable ontogenesis: not the solving of a problem within a given system or regional search space therein, but with regard to the genesis of a system. Information in this regard is not only about processing data, but about individuation. To understand the role of information in individuation we must think about the genesis and evolution not only of the individual, not only of the individual/milieu coupling, but of a system where there was none. Simondon and Denizhan leave us with the following question regarding processes of Automated Optimization: are we dealing with processes capable of tapping into the preindividual, that is, into the truly infinite, unbounded and indeterminate?

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