Was Turing a (Computational) Mechanist?

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Abstract

Alan M. Turing has introduced and explicated the notion of computational mechanism. It was informed by classical philosophical mechanism and some of its characteristics are found in the strand of 'new mechanism' in philosophy of science. However, rather than taking Turing's work to be a paradigm of mechanism tout court, especially computational mechanism, we examine the extent to which it may count as an exemplar of mechanism in the classical, modern and even his own sense. We argue for numerous mechanist and non-mechanist aspects, both in the classical and the Turingian sense, of his theorising throughout the various domains of his inquiries. We conclude that Turing's contributions are best viewed as an eclectic approach to mechanism that combines some aspects of classical and an anticipation of new mechanism while acknowledging some essential limitations to mechanism as a philosophical doctrine.

1. Introduction

In 1936, Alan Turing introduced his groundbreaking concept of computation as a 'mechanical procedure': a finite, stepwise procedure governed by a set of elementary rules that is capable of solving complex logico-mathematical problems. Such a routine, while modelled on the basic arithmetic routines executed by human beings tasked with 'computing' mathematical functions, could be implemented in a machine whose design Turing described on a theoretical level (1936). Thus understood, a computational routine appears to be mechanistic, in terms both of its formal description and of its machine-implementability.

With respect to the human mind, too, Turing might be viewed as a mechanist due to his belief that machines, when executing computational routines, could potentially realise behaviours characteristic of human-like intelligence (Turing 1950). This notion keeps challenging non-mechanists who believe that the ability to manifest human-like intelligence was an inherently non-mechanical capability exclusive to the human mind.

These observations might lead – and have led many scholars – to believe that Turing was a genuine and thorough mechanist in a philosophical sense. However, such generalised conjectures start to become blurred when one takes into account that, first, mechanism is not a unitary philosophical position – which has come a long way from early modernity to contemporary ‘new mechanical philosophy’. Second, Turing’s works cover a variety of areas of investigation, not all of which equally adhere to his mechanist model of computation. Besides the concept of mechanism he developed for the latter, Turing considered other kinds of mechanisms in other fields of inquiry. He also considered the possibility and the relevance of domains that remain beyond the reach of mechanistic accounts altogether.

Against this background, our general goal is the explication and contextual analysis of Turing’s mechanist approach. The questions we pose – and seek to partly answer – are these:

1. What was Turing’s understanding of mechanism?
2. To what extent did Turing go beyond his model of computational mechanism when seeking scientific explanations of various phenomena?
3. What is the possible bearing of Turing’s overall conception of mechanism on the transition from classical to ‘new mechanism’ in philosophy?

Our work is both historical and analytical in outlook. We are neither going to endorse nor to criticise any of the historical or contemporary accounts of mechanism, computation or philosophy thereof. Instead, our proposal is to make Turing’s various conceptions of mechanism and their scope more explicit and more precise than the current literature offers. Our working hypothesis is that Turing’s mechanism was partial and methodological in kind. Turing neither expressed nor presupposed metaphysical commitments either towards classical or towards his own brand of computational mechanism, but he was not an idealist or anti-mechanist either. For Turing, mechanism was a systematic way of going about the inquiry into phenomena in a variety of domains. He remained agnostic about the metaphysical nature of those phenomena. The most important benchmark for Turing’s methodological mechanism was the formal model of computation he defined. Taken by itself, however, that benchmark will not define the extension of its domain of application. Therefore, there are limitations to mechanism on either level, metaphysical and methodological. Conversely, Turing’s specific conceptions of mechanism may help to explain the transition from the classical philosophical mechanism that informed his own work to the new mechanism.

The article is structured as follows. After describing our research problem in some more detail (Section 2), we will review the key characteristics of the classical mechanist account

(Section 3.1) and Turing’s computational mechanism (Sect. 3.2). Then, we analyse in what respects Turing’s insights are congruent and in what respects incongruent with the classical mechanist approach and his own account of a mechanical procedure. Against the background of this analysis, we consider three domains of Turing’s work: meta-mathematics (Section 4.1), the development of biological form (Section 4.2) and models of human intelligence (Sect. 4.3). In Section 5, we offer a discussion of Turing’s approaches in the context of the classical and his own conception of mechanism in juxtaposition with pertinent analyses by other Turing scholars, and we will explore how Turing’s mechanisms informed the new mechanism in philosophy. We draw our conclusions in Section 6.

2. Problem description

Broadly speaking, mechanism in philosophy is the belief that the best and most truthful way of thinking about the world, man, cognition, and mind is to either explain them in terms of, or to conceive of them as, certain kinds of mechanisms. These mechanisms have their counterparts or prototypes in physical artefacts called machines—physical systems comprised of specific sets of elementary parts that are organised in such a way as to regularly transform a certain type of initial conditions into a certain type of resulting state in a number of specified operational steps. The transformations in question may concern physical states or energy, but also information. Depending on the interpretation of the analogy, philosophical mechanism is a claim concerning scientific method or a metaphysical doctrine concerning the presence of mechanisms in nature. Depending on the underlying concept of machines, the machine analogy is spelled out differently under either interpretation.

Among the various interpretations of the machine analogy, computational mechanism refers to machines that process data based on certain formal descriptions, compliant with a specific model of computation. However, Turing introduced his model of computation not as a general philosophical claim within the domain of mechanist approaches, but as a concrete solution to a meta-mathematical problem. Turing formulated his model in response to Gödel‘s ‘Entscheidungsproblem’, offering a definition of the concept of an effective procedure that could potentially determine the provability of any proposition within a given calculus. Turing’s model assumed the form of an abstract calculating machine whose operating rules specify how such procedures should be carried out. The description of Turing's abstract machine can be understood as a model that serves to define and explicate the notion of computational mechanism. While the result of Turing’s meta-mathematical investigation was that there is no effective procedure of determining the provability of a proposition within a given calculus, his abstract calculating machine served as the design blueprint for concrete machines, namely digital computers.

On the other hand, Turing's interests and ideas were broader than his concept of the computing machine and its hypothetical ability to mimic human intelligence, which has meanwhile come to dominate the image of his work in academic and popular discourse. Copeland (2000) argues that the explication of the mechanical procedure provided by the concept of the computing machine, which he calls 'narrow' mechanism, does not exhaust mechanism. This can be confirmed both by examination of Turing's other inquiries besides his conception of the computing machine, and by further, post-Turingian, developments in philosophical mechanism that partly diverge from classical mechanism. Turing's insights into the domains of biological phenomena (morphogenesis) or mental activities (mainly mathematical reasoning) reveal a more eclectic approach to mechanism that began to materialise in the late 1960s and is called today 'new mechanism' (Craver, Tabery 2019).

Despite these observations, Turing's ideas concerning mechanism do not seem to have been scrutinised in sufficient breadth and depth to date. There is room for more exploration in two directions: On the one hand, one can say more about the bearing of Turing's explicated definition of computational mechanism (strictly speaking, his model of computation) on the models he used in the various areas of his research. On the other hand, it will be meaningful to situate his overall perspective on mechanisms in the context of the wide-ranging history of discussion of mechanisms in science and mechanical philosophy.

Turing has been almost exclusively discussed in the context of computational mechanism, in sometimes anachronistic fashion, while there is little mention of him in other areas of inquiry into philosophical mechanism. For example, there is no mention of Turing in the *Stanford Encyclopedia of Philosophy* entry "Mechanisms in Science" (Craver, Tabery 2019). Similarly, Andersen (2014a, 2014b) makes no mention of Turing in her two-part "A Field Guide to Mechanisms", nor does any entry in the *Encyclopedia of Early Modern Philosophy and the Sciences* (edited by Jalobeanu, D., Wolfe, C. T., 2022). Some writers in the field of philosophy of computing invoke classical or contemporary conceptions of mechanism when discussing Turing's mechanical procedure. However, first, they offer analyses that are incomplete in terms of omitting various domains of Turing's inqiries. Second, they do not consider the context of philosophical conceptions of mechanism that existed at the time of Turing's writing. For example, Piccinini (2018) focuses on problems in the area of computational representations, passing over Turing's views in other areas, such as his proto-connectionist models of brain activity, his models of biological processes of morphological pattern formation, and his general philosophical views on mind and world. Webb (1980) does draw on classical mechanical philosophy when discussing the mechanisation of mathematical and mental operations, but similar to Piccinini, he exclusively applies it to Turing’s conception of the computing machine and the underlying logico-mathematical problems. Copeland (2000) discusses Turing's views on uncomputable problems and the ‘oracle’, but presumes his speculative combination of a computing machine with an oracle to be a machine itself, which contradicts Turing’s own statements on the matter (as we will demonstrate in this article). Copeland ultimately subsumes Turing under his own mechanist views, including the statement that classical philosophical mechanism is consistent with Turing’s ideas. In addition to that, Copeland focuses on domains of meta-mathematics and reflection on the mind only (ignoring, for example, Turing’s studies on morphogenesis). Finally, he only obliquely resorts to newer philosophical conceptions of mechanism that have developed after Turing. Most recently, Daylight (2024) proposes an explicitly anti-mechanist interpretation of Turing, arguing that he was in fact an idealist in philosophical terms. However, like the other authors cited here, he limits himself to Turing’s model of computation. Nor does he clearly distinguish between epistemic and ontic versions of philosophical positions, which we argue to be pivotal in the case of Turing’s philosophy, especially in explaining the presence of mechanistic elements in his work.

The indicated gap may have generally arisen from the assumption that the main purpose of Turing's inquiry, considered from a philosophical perspective, was to explicate logico-mathematical notions and formal systems and procedures in such a way as to make them plain and embedded in informal ‘common sense’ – a project that might be traced back to his philosophical exchanges with Ludwig Wittgenstein (see Floyd 2017). In such a project, his machine analogy would mainly serve as an informal didactic device to make a genuine formal problem more comprehensible, rather than as a model that shall actually help to provide an answer to that problem. However, such a project would make Turing’s machine analogy both look rather weak and unduly constrained. To the extent that Turing was a mechanist, he was so in a systematic and philosophically serious way, and not only with respect to logico-mathematical problems, as we will see in two domains of Turing’s inquiry: simulating human intelligence and biological development.

3. The classical mechanist account and Turing’s mechanism

3.1. Classical conceptions of a machine and mechanist philosophy

The term mechanism appeared in the 17th century, being derived from the Greek and Latin terms “μηχανή” and “machina” (Dijksterhuis 1961). Between the Middle Ages and early modernity, the meaning of the term shifted from that of a stable, static structure to that of a composite structure of interacting parts. The early modern and modern notions of a machine rely on the idea of an entity composed of elementary parts that interact with each other the way describable by Newtonian mechanics—“[a] machine is a composite work, the movements of which are founded in the nature of the composition” (“Eine Maschine ist ein zusammengesetztes Werck, dessen Bewegungen in der Art der Zusammensetzung gegründet sind”, Wolff 1752, 337; §557), or “a combination of resistant bodies so arranged that by their means the mechanical forces of nature can be compelled to do work accompanied by certain determinate motions” (Reuleaux 1876, 35).

Mechanical philosophy as a research program is commonly said to be initiated with the publication of Boyle’s 1666 *The Origin of Forms and Qualities* (Bellis 2022a) but this notion was already circulating among philosophers for nearly 30 years by that time (see Roux 2018, 26-27). Classical mechanical philosophy replaced the Aristotelian metaphysics of substantial forms and real qualities of objects by appealing to geometrical and kinetic properties of parts that constitute those objects instead (see Bellis 2022a, 1210). These views were neatly encapsulated in Descartes’ statement, as one of the representatives of the classical mechanist approach: “I have described this earth and indeed the whole visible universe as if it were a machine: I have considered only the various shapes and movements of its parts” (AT VIII-1, 315; CSM I, 279). An account of phenomena by the motion of parts was perhaps so compelling because it was considered “obvious and very powerful in Mechanical Engines” (Boyle, 1999–2000, vol. II, 87). Common denominators of the classical notion of a machine were its deterministic way of acting (Webb 1980, 1) and its composite and stable structure, which in part served as a model of the entire world (for example, in Descartes, Wolff and the “machina mundi” metaphor more generally).

The ontological crux of classical mechanical philosophy as it existed by the time of Turing’s writings was the claim that the material world is truly and fully mechanistic in character. Descartes, a dualist, believed the mind and mental experiences belonged to an immaterial part of the world, and therefore were exempt from the workings of mechanisms, but the constitution of all material things was that of a machine. By the same token, classical mechanism also amounted to the methodological norm that “natural phenomena should be accounted for by appealing to the structure of bodies made of chunks of extended matter in motion” (Bellis 2022b, 1216). This implies an essentially reductionist view of scientific explanation, which says that all higher-level observable phenomena can and should be fully explained by reference to the processes on one fundamental level of basic objects, activities and forces (Craver, Tabery 2019; Andersen 2014a, 275-276). This view was not a necessary implication of metaphysical reductionism though, as, for example, Descartes believed that matter is infinitely divisible, thereby making the notion of an ultimate reduction base inapplicable (Roux 2018, 28). Typically, however, classical mechanism was coupled with a lower-level reductive materialism as far as modelling observable processes is concerned. As Copeland (2000, 6) puts it:

> The core of the claim, as put forward by the historical mechanists, that such-and-such naturally occurring item is a machine is this: the item’s operation can be accounted for in monistic, materialist terms and in a manner analogous to that in which the operation of an artifact is explained in terms of the nature and arrangement of its parts.

Another methodological emphasis in classical mechanical philosophy was its turn towards a thorough mathematisation of explanations, in accordance with the precise mathematical descriptions that could be given of the operations of machines. This innovation helped to initiate the scientific revolution, understood as the rise of modern science as a systematically mathematised endeavour (Roux 2018, 30-31).

Apart from offering an alternative to Aristotelian natural philosophy, mechanical philosophy was a reaction against a metaphysical distinction between artificial and natural beings. It insisted on the homogeneity of nature and the universality of its laws (Roux 2018, 34). Accordingly, there were radical varieties of mechanism that not only emphasised the non-vital aspects of organisms but also viewed human beings as machines too, denying a special ontological status to mind and soul (see, e.g., La Mettrie’s 1747 *Man as Machine*).

The classical mechanist approach can be summarised in a working list of eight features, not all of which have to be necessarily present in all varieties of mechanism, except for the first:

1. All phenomena within the domain of mechanism can be characterised as effects of activities and interactions between parts of a compound system; this is the minimal definition of a mechanist approach in general.

2. Mechanism appeals to the physical, geometrical and kinetic properties of the parts that constitute the system.
3. Mechanism assumes a deterministic way of the system’s operations.
4. Mechanism assumes a stable, possibly even unchangeable structure of the system.
5. Mechanism levels the distinction between artificial and natural beings, assuming continuity or homogeneity between natural systems and artefacts, both being governed by a uniform set of laws of nature.
6. Mechanism implies the reduction of explanations to one fundamental level of basic objects and processes.
7. Mechanism engenders the mathematisation of explanations of the phenomena under investigation.
8. Mechanism includes the metaphysical premiss that the material world shares the properties postulated by the model, either in its entirety or in key domains.

One can detect some differences in the literature as to which of these characteristics actually define classical mechanism. Most notably, mechanism might be a methodological hypothesis or a metaphysical programme that is supposed to encompass certain domains of phenomena of nature in ist entirety. Given these caveats, the characteristics of classical mechanism listed above should best be viewed as family resemblances rather than as a set of jointly necessary conditions. Only item 1. Is a necessary ingredient of all forms of classical mechanism. It also comprises the minimal characterisation of the New Mechanist programme.

3.2. Turing’s computational mechanism

Turing aligned himself with a tradition of thinkers and inventors (most notably Leibniz and Babbage) who designed machines that could serve logico-mathematical purposes. In 1936, Turing introduced the concept of an effective procedure of calculation that can be described as a routine for an abstract machine. Specific procedures of this type were intended to solve mathematical problems, such as adding integers, or to carry out activities that can be mathematically described, such as generating correct sentences in English. Turing's idea was to isolate the most basic steps that are necessary for a human ‘computer’ when solving a task with a pencil and a sheet of paper, such as reading, writing and erasing symbols, and executing these steps in a task-appropriate sequence. Effective execution of this process would merely involve some basic formal operations rather than command of a fully formed mathematical language.

While developing his model of computation, Turing explicitly indicated that anything that can be called ‘purely mechanical’, or a ‘purely mechanical process’ is identified with being able to be carried out by an automatic computing machine:

> It was said above ‘a function is effectively calculable if its values can be found by some purely mechanical process’. We may take this statement literally, understanding by a purely mechanical process one which could be carried out by a machine. (Turing 1939, 166)
>
> It is found in practice that L.C.M.s [logical computing machines] can do anything that could be described as ‘rule of thumb’ or ‘purely mechanical’. (Turing 1948, 7).

A particular mechanical procedure can be executed by systems – human beings and various machines – that may differ in terms of their ‘physical’ characteristics. This property, known as ‘multiple realisability’, owes to the abstract nature of Turing’s computational mechanism. It is to be understood as a model of an abstract system of information-theoretic relationships rather than a model of a concrete physical mechanism.

The machine envisioned by Turing, henceforth referred to as “M”, consists of a state register, a read/write head (“scanner”), and an unbounded tape that allows symbols of a certain alphabet to be written into its individual “cells”. The M’s operation involves the execution of a set of instructions that determine the movements of the head, the read/write operations in the current cell and the transitions between states. All instructions are in the conditional form, which can be paraphrased in the following way: ‘if (state=p), (symbol=x), then change state to q, change symbol to y, move the head to right or left’. The mechanism controlled by them works as follows: when it ‘sees’ a symbol x in the current cell, it writes another symbol y into it (or leaves x unchanged), moves the head one cell left or right, then changes its current state p to another state q (or remains in the state q). The machine M finishes its work when it is in a defined final state; at that point, the result—a sequence of symbols from the alphabet ready to be interpreted—remains on the tape.

In the language of states and symbols from a specified alphabet, it is possible to write many sets of instructions of ‘programs’, which may be more or less complex. For example, if someone wanted to write a program for multiplying two numbers, he would have to choose the alphabet in which the numbers would be encoded (e.g., the symbols 0 and 1), decide on the number of machine states (e.g., 5), and propose an appropriate sequence of instructions containing alphabet symbols and machine states. To perform any particular multiplication, he would have to place two appropriately coded numbers on the machine's tape and run it; as a result of the program's execution, the appropriately coded result would remain on the tape.

Besides machines programmed for particular purposes, Turing introduced the notion of a machine programmed in such a way that it becomes a Universal Computing Machine (today called Universal Turing Machine; UTM), for which the condition holds that: '[…] without altering the design of the machine itself, it can, in theory at any rate, be used as a model of any other machine, by making it remember a suitable set of instructions' (Turing 1946). If we put the code of a particular M machine (that is, a code describing its alphabet, its possible states and its program) and some initial data for M on the UTM tape, the UTM would work as follows. It would read the input data from the tape, execute the program of the M machine, as a procedure controlled by the UTM's universal program, and it would thereby achieve exactly what the program of the M machine encoded on its tape prescribes. That is, the UTM would write on its tape (in the fields following the M machine's description) exactly the same symbols that the M machine would write on its tape, while being able to do so for any other M machine, too.

The design of the UTM, that is the description of its physical capabilities in conjunction with its initial set of instructions, allows it to simulate machines arbitrarily more complex than itself. This design offers a specification of the basic rules of how to perform any mechanical computational procedure. After Turing, to say that a procedure is a computational procedure means to assert that it can be represented (encoded) in a form executable by an UTM. Nonetheless, an UTM can be said to be performing a mechanical procedure only after a particular M's description and input data have been implemented. A mechanical procedure is fully specified and can be executed only after endowing UTM with the description of this particular procedure and the initial arguments, such as the digits to be multiplied, which is not an intrinsic part of the specification of UTM.

In view of the above explanations, Turing's way of understanding of 'effective procedure', or 'purely mechanical process' can be summarised as follows:

(a) The process concerns units of information that are transformed in goal-directed or 'functional' fashion.
(b) The domain of the information involved and the mode of processing are discrete, for operating in step-wise fashion on individual 'cells'.
(c) The process comprises of a finite number of operations performed in finite time.

(d) The process is deterministic in that any current computational state determines the subsequent computational state.

(e) The process is closed, in that any operation of the machine is dependent only on predetermined rules of action (‘machine table’), symbols on the tape (including the inscribed program) and the states of the scanner.

The connection between classical philosophical notions of mechanism, as reconstructed in the previous subsection, and Turing’s computational procedure can be described as follows. Turing’s concept certainly shares the basic characterisation of mechanism in (1.). Moreover, his approach to modelling the process of computing was methodologically reductionist (6.) to the extent there was no appeal to higher-order levels with intrinsic properties and behaviours present in the model. All mathematical problems that can be solved in a finite number of steps can be solved by an UTM and its elements. In turn, conditions d. and e. imply that Turing’s approach was deterministic (3.). To the extent that empirical problems can be given a computational description, Turing’s approach can be interpreted as a basis for the project of mathematisation of science (7.). However, Turing’s mechanism diverges from the classical paradigm in two other ways: First, it primarily appeals to the informational, not the physical properties of the systems under consideration (cf. 2.). Second, there is scattered but solid evidence against the belief that his project implies a commitment to mechanism as a metaphysical programme (8.). As we will show in three brief case studies from Turing’s inquiries, even his commitment to determinism and explanatory reductionism was limited.

4. Mechanist and non-mechanist elements in Turing’s approach

4.1. Understanding mathematical reasoning

The prima facie implication of Turing’s ‘effective procedure’ for mathematics seems to be that even the most complex, higher-order logical-mathematical operations could be decomposed into elementary interactions between the basic elements of his deterministic machines. In fact, Turng has shown that a wide class of mathematical activities can be subsumed under mechanistic procedures performed by a UTM. It covers activities ranging from performing simple arithmetical operations to proving sophisticated mathematical theorems on the basis of presumed sets of axioms. This implies that this class of mathematical activities is by definition mechanistic in Turingian sense. In what follows we are focusing on these views of Turing that indicate non-mechanistic elements in mathematical reasoning.

Already in the early stage of his inquiries Turing did not seem to believe in the possibility of offering one universal set of basic logical principles to which *every* mathematical operation could be reduced. As early as 1933, he gave a lecture to philosophers at Cambridge during which he criticised Russellian logical reductionism that rested on the belief in the possibility of discovering one universal logical system. In the minutes from the meeting, Turing was reported to have defended the statement that this 'logistic' view of mathematics is inadequate and the logical interpretation is not the only one possible (see Hodges 2014, 110). Such rejection of logical universalism and reductionism is consistent with Turing's early considerations of issues of linguistic representations that scientific models are based on. During his studies at Cambridge, inspired by his interactions with Wittgenstein, he was contesting the idea of universally proper, cast-iron semantics. In contrast, he argued that systematisations, categories and linguistic ontologies adopted in language use are and should be dynamically construed and recognised based on common sense and practical needs of the language users (see Floyd 138-142).

In his later work on ordinal logics, Turing argued that his model of UTM is not sufficient to capture all the essential features of mathematical reasoning. Regarding his attempt at a mechanistic description of mathematical reasoning—which the UTM model was supposed to provide—it appears that, at a certain stage of his investigations, Turing concluded that a mechanistic description is not sufficient. It does not make it possible to describe all reasoning or all methods that lead humans to solutions of well-posed mathematical problems. The obvious reason for this conclusion lies in the discovery of the incompleteness of formal systems, which was a probable result of Turing's inquiry into effective procedures:

> We might hope to obtain some intellectually satisfying system of logical inference (for the proof of number-theoretic theorems) with some ordinal logic. Gödel's theorem shows that such a system cannot be wholly mechanical. (Turing 1939, 200).

Those aspects of mathematical work which are beyond what can be described in mechanistic terms but still are inherent elements of the process of solving mathematical problems are highlighted by Turing as the domain of the mathematician's 'intuition':

> In consequence of the impossibility of finding a formal logic which wholly eliminates the necessity of using intuition, we naturally turn to 'non-constructive' systems of logic with which not all the steps in a proof are mechanical, some being intuitive. (Turing 1939, 216).

When considering the insufficiency of mechanical procedures, Turing considered an ‘oracle’, a kind of ‘black box’ attached to a machine. Its role would be to provide “some unspecified means of solving number-theoretic problems” (Turing 1939, 172), and thus something analogous to intuition in solving mathematical problems (cf. Marciszewski 2019). It was meant to allow the machine to find the values of uncomputable functions; that is, to solve problems unsolvable by mechanical procedures. Turing never specified how the oracle would accomplish this task, but he said that it was certainly not a machine:

> We shall not go any further into the nature of this oracle apart from saying that it cannot be a machine. With the help of the oracle, we could form a new kind of machine (call them o-machines), having as one of its fundamental processes that of solving a given number-theoretic problem. (1939, 172-173).

The oracle is an element of the machine that serves to solve non-calculable, and therefore not mechanically solvable, problems. In (1936), Turing mentioned a kind of machine that he did not intend to describe as ‘automatic’, and thus ‘mechanical’ (see Chapter 3.2), “[…] whose motion is only partially determined by the configuration. […] When such a machine reaches one of these ambiguous configurations, it cannot go on until some arbitrary choice has been made by an external operator” (60). The addition of an oracle could have been interpreted as such an external operator and if so, as making the machine operate in a not purely deterministic fashion.

With respect to the ontological status of the mathematical operations involved in his inquiry, Turing did not presume a computational version of metaphysical mechanism, neither in a strong nor a weak sense. Weak metaphysical mechanism would mean in this context that some ontological status accrues to mathematical structures and processes, so that, for example, the steps of a proof were a process that is somehow part of the real world. If we follow Turing’s lead in 1939 and his Cambridge lecture, then processes of this kind might be real but not entirely mechanical. One might reply, similarly to Copeland (2000), that metaphysical mechanism could still apply to a conception of a machine with an oracle, but Turing did not consider this conjunct entity a mechanism to begin with, so such a thesis misses the point as far as an interpretation of Turing’s work is concerned. Conversely, strong metaphysical mechanism would mean that a computational procedure specified by a Turing Machine literally represents a computational mechanism. Turing’s notion of computational procedures performed by an UTM would amount to an explication of the concept of mechanism, and therefore “[…] computational explanation is a species of mechanistic explanation.” (Piccinini 2018, 442). If a mechanistic explanation literally represents a world affair because that world affair itself is a mechanism, the restatement of classical mechanical philosophy's maximally strong ontological assumption in Turing's terms would be that every physical system operates, that is, processes information, in a way that can be described in terms of UTMs, regardless of the properties of the physical substrate in which these computations are performed. Accordingly, Turing's concept of mechanical computation would not only literally represent mathematical facts, but make the entire universe appear as a giant computing machine (see Piccinini 2018, 435-437). However, there is no evidence of something that even vaguely approximates this pan-computationalist assumption in Turing.

Finally, there is no appeal to the physical, geometrical and kinetic properties of parts that constitute the computing machine nor a reliance upon the machine's stable, unchangeable structure. The machine is thought of as, first, as an abstract model rather than a concrete type of device. Second, its function is to process information, where this function might be physically realised in multiple ways, which are not part of the specification of the machine. Its formal description does not require or presuppose any specific physical description of how the abstract model would have to be implemented in the real machine. Third, the machine's features of universality and multiple realisability imply that its operational patterns are partly indeterminate and flexibly determinable. Only the most general structure of the machine is fixed, in terms of functional descriptions of the types of elements, such as the tape and cells, the scanner and the instruction table. The instruction table for the interpretation of programs of various specific machines by an UTM is predetermined. However, the content of the tape of the UTM is not predetermined. This content causes this machine to realise a concrete goal. These goals are predetermined only for particular Turing machines, but not for the UTM.

4.2. Modelling biological development

Turing's last published work and some posthumously published manuscripts were dedicated to the development of his theory of organic pattern formation. In "The Chemical Basis of Morphogenesis" (Turing 1952), he provided an elaborated mathematical formulation of the theory of the origins of biological form. His mathematical theory predicted some of the key properties and behaviours of the real biochemistry of pattern development in nature, at a time at which empirical validation was not yet forthcoming (which Turing and Wardlaw 1952, 46, were aware of; see Crampin et al. 1999; Kondo, Miura 2009).

The ‘idealised and simplified’ (Turing, Wardlaw 1952, 43) model of a biological system proposed by Turing incorporates a pair of two morphogens (u and v), diffusing through a medium and taking part in a chemical reaction in which one can be regarded an activator (u)—a substance that is a direct or an indirect catalyst for its own formation and production of the other, v, as an inhibitor that causes destruction of u. At the initial stage, the organism is morphologically symmetrical, with the morphogens being homogeneously distributed and production and inhibition rates enabling a stable equilibrium. The break of this steady state is triggered by small disturbances governed by the laws of physics (Brownian motion, minor irregularities of form or interference from neighbouring structures). The changes in the concentration rates are functions of the reactions between morphogens and some constants representing the physical properties of the cells. Dynamics of changes in concentration rates can be represented by a system of partial differential equations:

$$\frac{\partial u}{\partial t} = f(u,v) + D_u \Delta u, \quad \frac{\partial v}{\partial t} = g(u,v) + D_v \Delta v$$

In this set of equations, f and g represent rates of production functions and D is a matrix of constant diffusion coefficients or, in Turing’s terminology, “diffusion constants”. They abstractly represent some physical property of the tissue, which can be more concretely described as the resistance it poses to the flux of a given morphogen. This property influences the rate of change in morphogen concentration.

Under the simplifying assumption of linearity of the regime of reactions, Turing solved the equations to find that a system that becomes unstable and progressively departs from its initial steady state can over time asymptotically converge on several new states of steady or stable equilibria that establish spatial patterns of morphogen concentration in the tissue. In some of these cases, three or more morphogens are involved. The system that was “[…] of greatest interest and has most biological application” (1952, 52) was the one whose initial conditions lead to the formation of a steady state with “stationary” waves of morphogen concentrations with finite wavelength. This type of end-point equilibrium presumably has the most direct bearing on known biological systems (52, 67–68). Turing thought of morphogens as the chemicals responsible for the generation of anatomical structures, organs or all other sorts of organic patterns (like physical configurations describable by Fibonacci sequences; see 1992a) in locations where they are present in sufficient density.

There are four unequivocally mechanist aspects of Turing's approach to modelling morphogenesis: The first and most straightforward classically mechanist trait of Turing's theory of morphogenesis is its high degree of mathematisation. Besides mathematical population genetics, Turing's theory was one of the first effective attempt at formulating a biological theory in mathematical terms. He offered a purely abstract description of the relevant processes that does not refer to the concrete physico-chemical properties of the morphogens but is empirically adequate to reaction patterns in the organic substrate. Second, Turing's theory of morphogenesis is a prime example of modelling higher-order phenomena by reference to the basic elements of a system and their interactions. The overall morphological properties of an organism are explained by biochemical process on the cellular level. Third and related, his theory is methodologically reductionist. Turing referred to Newton's laws of motion, elasticities, osmotic pressures, and diffusion reactions, which all belong to a lower physico-chemical level but are supposed to sufficiently explain all relevant properties on the higher-order level of the organism (Turing, Wardlaw 1952, 37-38, 41). Turing explicitly rejected specific laws or entities that would exclusively pertain to that higher-order domain, as they were invoked in vitalism and, on some critical views, implicitly presupposed in Darwinian evolutionary explanations. Fourth, Turing characterises the morphogenetic process in unequivocally deterministic terms. It leads from a set of-pre-defined properties of the system to a definite end-point of expression of morphological features, where the latter state is a function of the initial properties of the dynamic system. Therefore, a specific macro-level organic pattern, such as a specific type of dots on the skin or a specific type of Fibonacci symmetry of petals, is presented as predictable from the physiological properties of the tissue, the initial conditions on the cellular level and the rules of the morphogens' interactions. Turing expressly admits of a random element in the process, which is the externally induced disturbance of the original equilibrial state, which triggers the development from a homogeneous to a differntaited state. However, this initial cause itself is not part of the model. The morphogenetic process can also be considered finite. The resulting pattern is fixed by the distribution of the morphogens in a steady state of the system. Such a pattern may for example correspond to a mature form of an organism. Apart from the external stimulus that triggers it, the morphogenetic process is also closed, in terms of not depending on any interactions with its environment. The self-contained nature of morphogenetic processes, as envisioned by Turing, is reflected in his notion of recursiveness. The production of a unit of pattern that occurs at an early stage provides the basic schema for patterns that develop at later stages:

> GOEBEL (1922) pointed to the repetitive occurrence of pattern during development and to the relative constancy of scale of the "units of pattern' * at the time of their inception. THODAY (1939) has indicated how this conception could be used to account for the increasing structural complexity in roots of increasing size, i.e. as the stele enlarges, more units of pattern can be accommodated. If this be accepted, then the fundamental problem is to discover the factors which determine the unit of pattern. (Turing, Wardlaw, 1952, 39).

Despite strong mechanistic inclinations, Turing’s theory of morphogenesis also exhibits some limitations in its commitment to mechanism. Especially with respect to the conditions of determinism, closedness and stability.. To begin with, Turing admitted that his theory was deterministic only in simplistic fashion, to the extent of ignoring the effects of random disturbances that may occur in the course of the processes of form development (1992a, 101 and earlier pages). He considered his conceptualisation of the process as a deterministic mechanism merely a simplified representation that was sufficient for its purpose, and he was not committed to the ontological assumption that the process being thus modelled is in fact mechanical, either in the classical or computational sense. This is consistent with a later statement by Turing and Wardlaw that although some species-specific types of pattern are predetermined within some rather general boundaries, “each [such type] may be greatly varied in the matter of details” (Turing, Wardlaw 1952, 40). Such variance might not only be due to differences in initial conditions. Actually, Turing made some tentative proposals for an analysis of small stochastic effects already in 1992a (100-107) while admitting to his inability to include the most important random factors in his models. Apart from the process not being fully deterministic in nature, Turing tried to remedy the problem of the process also not being anchored in a stable, unchangeable structure of the system. Motivated by the fact that the growth processes themselves may change the dynamics of pattern formation mechanisms, Turing (1992b) proposed a fragmentary dynamic morphogenetic model where the original formulation was supplemented with a spatiotemporal term that grasps temporal variation of the geometry of the area in which some morphogenetic process takes place. The change is caused by the growth of the underlying tissue. Another element that is not part of Turing’s framework of computational mechanism is the non-discreteness of the domain of his models, that is, the domain of the system of partial differential equations in (1952). The variables that describe the biological systems under consideration are continuous rather than discrete. Moreover, Turing also considered the tissue not to be necessarily discrete, that is, comprised of separate cells. Last but not least, Turing’s morphogenetic theory entirely abstracts from the potential functional roles of the patterns whose formation it seeks to explain. As shown in the previous paragraph, he presented his theory as capable of explaining the presence of homologies of patterns within different taxa without any reference to evolutionary or other teleological (goal-directed) explanations. Turing's reluctance to interpret organic patterns functionally was confirmed by Turing's PhD Student Robin O. Gandy when he stated that, by developing his theory of morphogenesis, Turing intended to "defeat the argument from design" (Hodges 2014, 543).

4.3. Brain, intelligence and metaphysics of mind

In (1948), Turing proposed a model of a machine that is capable of learning from interactions with its environment in a partly similar way to the human brain. This model anticipated some of the key ideas of classical connectionism. The elementary unit of Turing's hypothetical machine includes two input terminals and one output terminal. Output terminals could be connected to input terminals of other units. Synchronised pulses emitted by units could make other units assume either of two discrete states (0 or 1). The state of the unit to which two such pulses arrive depends on the states of the respective sending units. The operation proposed by Turing was this: The state of the receiving unit (and therefore its own output) assumes value 0 only if and when it has received two input values of 1; it otherwise assumes state 1. This operation is known as 'not and' or as 'NAND' in contemporary parlance. A special type of such a machine whose 'configuration' concerning its outer environment can be 'modified' (1948, 8, 13) includes special circuits of interconnected NAND neurons contained in all connections between nodes. These circuits allow for a type of interference through the two channels connecting them to the environment. Technically, this is done by information changing the reversible states of the connections, which makes them either assume the role of logical NAND gates or remain inactive with respect to that role. These elements are essential for the modification of the structure of the net by enabling or disabling particular connections. The network can be changed both by input signals from the outside world and by signals from within the net. The machine's process of 'organizing' from an initially unorganised state consists in successive changes in the 'configuration' of the 'initial conditions' of relevant 'connections' on the one hand and in filling in missing data on the other, where the data is stored in the form of initial states of nodes that serve as memory units.

Turing considered this kind of proto-connectionist system in wholly logical and abstract terms, but also characterised it as ''the simplest model of a nervous system with a random arrangement of neurons'' (Turing 1948, 6). The nervous system thus simulated develops intellectual abilities through interactions with its environment. Those interactions serve to 'educate' the machine through iterated rounds of positive and negative feedback. In an interplay between what Turing called 'initiative' and 'discipline', the machine could 'produce' intelligence. Discipline, that is, supervised learning would enable the machine to attain the status of a universal machine (UTM) as a necessary precondition of intelligence. The jointly sufficient condition would be the presence of initiative, which was meant to consist of 'various kinds of search' (Turing 1948, 18), which he classified into three categories: (i) 'intellectual', which meant posing or redefining intellectual problems, (ii) 'genetical', which proceeds by random trial-and-error at the level of nodes' connections, and (iii) 'cultural' which utilises the knowledge of others by interacting with human and machine agents (Turing 1948, 34-36).

Prima facie, Turing's model of the nervous system and its capacity of producing intelligent behaviour seems to be the most straightforward application of mechanist thinking in general and computational mechanism in particular. It certainly exemplifies the minimal mechanist idea of modelling a system's higher-order processes in terms of the interactions of its parts (1). The machine analogy becomes very explicit already in the programmatic statement of Turing's superior that the goal of his sabbatical leave was to extend the work on the computing machine ''[…] towards the biological side [...] to see how much a machine can do for the higher parts of the brain" (Darwin 1947, quoted after Copeland 2004, 400). The model also satisfies the properties of being discrete (b) and finite (c) by design. Given that brains "[…] nearly fall into this class [of discrete 'controlling machinery']" (Turing 1948, 3), Turing's approach also blurs the the distinction between natural and artificial systems (5). Since his model does not stipulate the existence of distinct levels of organisation with intrinsic properties of their own, it is reductionist in a methodological sense (6). Finally, the model is straightforward of functionalist, in assuming goal-directedness of the process (a): the machine is meant to search for configurations that will produce outcomes that offer solutions to predefined problems or, in some cases, detect new problems.

When it comes to non-mechanist aspects of the connectionist model, several non-mechanist aspects as seen from both classical mechanist and Turing's mechanism perspective can be pinpointed. The model is abstract and does not appeal to any specific physical properties of the machine (2) nor its stable structure (4). Also, it is thought of as being significantly based on indeterministic elements (on the assumption that interaction with the environment is not deterministic) (d). Moreover, the process appears not to be necessarily closed (e): possible changes of the external factors that might affect the solution and lead to further reconfigurations. In more general terms, for the machine to have initiative implies its ability to surpass the characteristics of the universal computing machine because this machine was neither meant to be capable of active search, nor of (partly) randomly changing its configuration in response to its environmental feedbacks on its behaviours.

Turing's apparent assumption of non-reductionist and non-mechanist aspects of human intelligence in metaphysical terms deserves separate attention. In his youth, during his studies at Cambridge, he expressed belief in the existence of levels of reality that remain beyond the grasp of elementary physical mechanistic explanations. As he wrote in a short, unpublished essay:

> The conception then of being able to know the exact state of the universe then really must break down on the small scale. [...] We have a will which is able to determine the action of the atoms probably in a small portion of the brain, or possibly all over it. There is now the question which must be answered as to how the action of the other atoms of the universe are regulated. Probably by the same law and simply by the remote effects of spirit but since they have no amplifying apparatus they seem to be regulated by pure chance. The apparent non-predestination of physics is almost a combination of chances. […] Personally I think that spirit is really eternally connected with matter but certainly not always by the same kind of body. ("Nature of Spirit", written in 1932, quoted in full length in Hodges 2014, 82-83).

These views of 'spirit' were likely informed by certain indeterministic interpretations of quantum physics, and by Arthur Eddington in particular, who expressed strongly idealist views in his *The Nature of the Physical World* (1928), which was previously read by Turing. Going even further in his "Computing Machinery and Intelligence", he wrote in a surprising but little discussed passage: "[…] telepathy, clairvoyance, precognition and psycho-kinesis. These disturbing phenomena seem to deny all our usual scientific ideas. How we should like to discredit them! Unfortunately the statistical evidence, at least for telepathy, is overwhelming." (Turing 1950, 453). If these are traits of the human mind or spirit, there is little insight into them that one can expect from a mechanistic account.

5. Discussion

In a nutshell, Turing's notion of a deterministic, mechanical procedure of solving logico-mathematical problems builds and extends upon on a classical *naturphilosophical* conception of mechanism on the one hand (Webb 1980). On the other hand, his inquiries into empirical domains, and some of the metaphysical presuppositions that went into them, in many respects diverged from classical mechanism (Section 3.1) and often did not even follow his own conception of computational mechanism in (a,…, e) above (Section 3.2). While he shared the basic tenet of mechanism (1) that higher-order phenomena are to be modelled in terms of the interactions of their parts, and while resorted to determinism, reductionism and mathematisation as explanatory strategies, Turing was not a mechanist in an ontological sense. In some domains of reality – both mental (such as intellectual activity) and physical (such as the partially non-deterministic processes of morphogenesis) – he pointed out elements that were hardly explainable in terms of classical, or even computational, mechanism. However, his genuine metaphysical commitments are left largely unexplicated. Turing's approach was essentially eclectic and ambivalent with respect to classical mechanism and in part also his own explication of mechanical procedures.

An observation that will be instructive with respect to Turing's implicit metaphysical commitments lies in his use of two different conceptions of how a machine might hypothetically move beyond the limitations of mechanical computability: 'intuition' and 'initiative'. Both intuition (present in 1939 but not in 1948) and initiative (used only in 1948) denote a certain non-mechanistic elements of mathematical reasoning that account for its potential originality and creativity. These elements complement the disciplined execution of pre-defined rules that can be formalised as a program for an UTM. In this context, intuition is a passive element, consisting in the insight into the essence of mathematical objects, grasping its properties, e.g., the truth of a certain axiom, without the participation of conscious reasoning. Intuition may provide a starting point for initiative, which, in turn, is an active element that is responsible for taking certain actions or 'choices' and 'decisions', as Turing writes. Initiative is not necessarily effective, and it might be erroneous, but it is directed towards the development of an ability to solve some problem. It may involve methodically searching the space of possible solutions, for example, by preceding it with an appropriate transformation of the problem or a preference for certain 'properties' of some solutions or other search strategies that are nowadays called 'heuristic'.

From the perspective outlined here, the thesis that Turing's approach leads to the conclusion that the brain is 'computationally equivalent' (c.f. Copeland 2000, 31) to a universal computing machine with an oracle seems misguided. First, this statement is unverifiable given Turing has never described how an oracle-backed kind of computation would look like. Second, Turing stated that an oracle cannot be a machine and that an oracle-involving process is not mechanical in the sense of being implementable in a UTM (1939, 172-173). Third, Copeland’s statement suggests an ontological reading of mechanism that is not borne out by Turing’s own claims. Despite labelling the brain ‘machinery’ (e.g., in 1948), an interpretation more consistent with his claims and facts concenring his models would be that Turing conceived of mind and brain as ‘machines’ only in a metaphorical sense. He did not think of them as literally being Turing machines or connectionist machines, but merely *like* these machines in some explanatorily relevant respects. Turing stated that some ‘essential properties’ (1948, 3) of a brain with respect to its ability to produce intelligent behaviour can be modelled by appropriate machine design. This statement does not entail an assumption of ontic equivalence between the model and these properties. Turing himself stated that the brain and free will could only be ‘imitated’: “[...] a machine which is to imitate a brain must appear to behave as if it had free will, [...] One possibility is to make its behaviour depend on something like a roulette wheel or a supply of radium” (1951, 484).

The ‘essential properties’ hinted at by Turing that constitute intelligence or thinking are therefore not necessarily observer-independent or ‘ontic’ features of an agent or object. As Proudfoot (2022) argues, intelligence, as understood by Turing, does not denote the ontic constitution of an entity endowed with intelligence or the ontic presence of this or that mechanism in this entity, but is an observer-relative concept instead: it refers to the perception of an interrogating agent. If so, then saying that the machine is intelligent or provides a model of intelligence does not mean that its way of is or represents the mechanism of the brain’s functions. Instead, it would mean that, based on imitation, it gives the observer the impression of being the same phenomenon as the working brain. This impression is then interpreted as intelligence. Depiction of the true, real mechanism responsible for the phenomenon of intelligence produced by the brain is therefore not covered by Turing’s understanding of the machine model. This detachment from metaphysical mechanism in the case of modelling intelligence has been reframed in terms of the behavioural interpretation of Turing’s notion of machine intelligence (e.g., Riskin 2017, 329-336). Turing tried to describe how a machine can exhibit intelligent behaviour like that of a human being, not the actual mechanism that stands for this behaviour in the case of human agents.

Daylight (2024) draws a conclusion akin to Proudfoot’s, but more generalised and radical. His claim is that Turing’s philosophical views were tantamount to philosophical idealism. He supported this claim by indicating that Turing admitted of the impossibility of grasping solutions to all the mathematical problems by means of a universal symbolic framework , and by highlighting Turing’s preference for designing computing machines for modelling intelligence that are not based on full automation. He also points out that Turing read authors from Cambridge that (according to W.J. Mander) belong to the tradition of British idealism: Arthur Eddington (who was also Turing’s mentor during his studies), James Jeans and John McTaggart. However, especially with respect to the latter point, Daylight’s argument for Turing’s idealism, and therefore a thorough metaphysical anti-mechanism, might be overambitious. First, the fact that Turing read some authors who expressed idealist views does not imply that that he must have held the same philosophical views. After all, Turing also read works that expressed material mechanist views (see Greif et al. 2023). Second, Daylight does not clarify what definition of ‘idealism’ he adopted as a benchmark for Turing’s own thought. As for other philosophical views, idealism might come in two distinct flavours. It might be an ontological doctrine, claiming that the ultimate foundation of reality, or the only thing that is real, is the mind. It may also come as the epistemic claim that, even if a mind-independent reality exists, all our knowledge claims are a kind of ‘self-knowledge’ of the constructs of our mind, foreclosing cognitive access to how mind-independent reality stands (see Guyer, Horstmann 2023). If Turing were an idealist in the metaphysical sense, it would have to be shown that he expressed the view that the mental is dominant or the only real substance. His admittance of the existence of extrasensory mental abilities, or of the existence of a soul that is ‘connected’ to matter does not entail the claim that these are ontically more real than, or superior to, material reality and the mechanisms operating within it. If Turing believed that mental activities are not fully reducible to logic or mechanical procedures that can be performed by a machine, and if he believed that there exists no universal logic to represent all mathematical reasonings, these beliefs do not entail the further belief that there is no mind-independent reality or that the mental reality is superior to it. Turing’s beliefs have no bearing on the question of the relation between the mental and the physical, to which Turing did not answer.

Epistemic idealism cannot be derived from Turing’s beliefs about spirit and matter either. When referring to the Darwinian theory of evolution (see, e.g., Turing 1950, 456-61) in his outline of the development of machine intelligence, he did not suggest that these mechanisms were mere constructs of one’s mind. Nor did he suggest that patterns in nature, such as those described by Fibonacci numbers, were an invention of the human mind. It will be fair to admit though that he thought of his mathematical model of morphogenesis as simplifications and of the underlying physico-chemical mechanisms as mere theoretical proposals, so in this sense they are partly constructs of the mind. Nonetheless, they were meant to be helpful in “interpreting real biological form” (Turing 1952, 72), and therefore stood in the service of explain something that he considered empirically accessible as a mind-independent reality. This position excludes both metaphysical and epistemic idealism.

In light of our analysis of Turing’s views in the previous section, we conclude that it is more tenable to ascribe to him the metaphysical belief that the universe has a plural, at least a dual nature, with both material and mental substances being present and interrelated, but with no dominance relation specified. The more plausible, and a more moderate, epistemic stance than idealism would be that we have access to (and can model) some aspects of a mind-independent world and that we encounter limitations in accessing and modelling others. Such a philosophical position happens to be fairly in line with D’Arcy Thompson’s (1918) philosophy, on whose theory of biological form (Thompson 1942) Turing strongly relied. Thompson believed that ‘matter and mind are incommensurables’ and that we are dealing with ‘bits of reality’ with the ‘material body of a living thing being a mechanism’ (1918, passim).

We have thus far outlined the commonalities and differences between classical mechanism and Turing’s insights. What about the new approach to mechanism that came after him? We suggest that Turing’s work on mechanical computation, in its methodological outlook, prefigures and partly informs the approach to scientific explanation and modelling proposed by the New Mechanists. Their common denominator is the view that “[a] mechanism for a phenomenon consists of entities (or parts) whose activities and interactions are organized so as to be responsible for the phenomenon.” (Glennan, Illari 2018, 2). This view is continuous with the common denominator of classical mechanist approaches indicated in condition 1 (Section 3.1). It also adheres to reductionism concerning explanations: “[m]echanists have tended to hold to some kind of reductionist strategy, that is, the belief that to understand higher-level processes it is necessary to investigate them at lower levels of organization: for example, cells in terms of molecules, organs in terms of cells, organisms in terms of organ-system.” (Allen 2005, 266) Mathematisation and determinism as explanatory strategies are also typically found in New Mechanism. However, this paradigm is not continuous with classical mechanism in that remains metaphysically agnostic (see condition 8 above), being “less of a doctrine and more of a method” (Craver, Tabery 2019). The key points at which New Mechanism aligns with and departs from classical mechanism are the same points at which the core of Turing’s conception of mechanism aligns with and departs from it.

Still, New Mechanism is a heterogeneous paradigm in many respects. Turing’s various mechanistic approaches, as we reconstructed them here, correspond with the various flavours of New Mechanism in instructive ways. The strand of New Mechanism that focuses on the abstractiveness of modelling and multiple realisability (see, e.g., Craver, Darden 2001; Tononi 2009) pars with all three models of Turing, but has its most direct and obvious counterpart in the basic methodological tenets of Turing's computational mechanism. The strand of New Mechanism that highlights the initial conditions/termination conditions and the laws that govern the transformations between them has its counterpart in Turing's specification of the properties of a computing machine and its schema of inputs/output conditions and the regularity and determinacy with which this kind of machine is supposed to operate (see, e.g., Machamer et al. 2000). Besides Turing's model of computation, his theory of morphogenesis relies on the same kind of nomological-deductive scheme. In contrast, the way information is being processed in Turing's connectionist machine is subject to the partly random dynamics of its configuration and the element of initiative; it is not governed by predefined laws, but rather the 'laws' that determine the schemes of information processing are being dynamically and tentatively established, or designed throughout the rounds of the iterative learning process. This latter design in turn resembles another strand of New Mechanism that explicitly refrains from appealing to laws of nature (Bechtel, Abrahamsen 2005) and therefore is not based on a nomological-deductive scheme of explanation. Yet another New Mechanist approach, which is oriented towards a thinking in terms of goal-directed functions (e.g., Craver 2001) echoes both the Turing model of computation and his later connectionist model of the brain. The question whether or not Turing-style computational mechanisms should be supposed to operate on representations lies at the heart of the application of New Mechanist conceptions to cognitive modelling (Maley 2023). It is obvious that in Turing's theory of morphogenesis, there is no reference to representations, but might seem equally obvious that UTMs and Turing's connectionist systems have the function of processing representations – of numbers or of world affairs. However, this might only hold true for non-Turing computational, analogue systems by default, whereas Turing's models depend on arbitrary, observer-dependent assignments of representational function. Finally, the general focus on integrating and connecting different levels of mechanisms in multi-level systems that is common to many strands of New Mechanism (Andersen 2014b, 276) is an innovation over Turing's approach. His view of explanatory reduction did not provide for layered mechanisms and the complexity they imply, but his openness to accepting the existence of different interacting levels of the phenomena under investigation sets him apart from the classical mechanist's metaphysical views. Hence, there are numerous if partial parallels between Turing's mechanistic conceptions and New

Mechanism, some of which testify of a direct influence of Turing's work on New Mechanism. It will be the task for another paper to actually trace the extent and the routes of that influence.

6. Conclusions

Turing was not mechanist in the same way as envisioned by classical mechanism. Even by the standards of his own definition of computational mechanism, he would not fully count as a mechanist. He developed and applied mechanism as a methodological paradigm that was informed by but only partly congruent with classical mechanism. At the same time, due to Turing's rejection of mechanism as a metaphysical doctrine, his beliefs concerning the multi-layered nature of the universe and his eclectic approach to modelling, his contribution is more in line with the New Mechanism. His insights can therefore be considered to provide the bond between the two paradigms that would otherwise only share a modicum of common ground in philosophical terms.

A somewhat paradoxical upshot might be that some established general frameworks, definitions, or distinctions concerning mechanism appear problematic and multifaceted when considered from the perspective of Turing's own insights, despite him being very precise and meticulous at many points. He was a thinker who developed a system of modelling world affairs that is apt to a multitude of applications, in a multitude of transformations. This, however, does precisely not mean that Turing was a systematic thinker who professed in building a coherent and seamless worldview in the same fashion that many philosophers would. Trying to pin him down to one unequivocal conception of mechanism would not do justice to this multifaceted way of thinking, nor was it something that he himself would have been seriously concerned with.

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