Digital studies
Report – January 13, 2015

We owe to Alan Turing the concept of "**abstract machine**" as well as the well-known "**intelligence test**" – which are the basis of the major research programs and intellectual constructions of the 20st Century: **cognitivism** and **artificial intelligence**.

Alan Turing is generally associated to the idea that human mind can be understood in mechanical terms. The "abstract" machine he conceptualizes in 1936 suggests that the operation of human mind can be modelized thanks to algorithms and reproduced in a discrete state machine, of which nothing a priori forbids the material concretization. Moreover, the test he proposes in 1950 in "Computing Machinery and Intelligence" suggests that human thought can be successfully simulated by a digital computer.

Turing's thought about cognition is however more complex than it seems. In three steps of his work, Turing refers to a field of human thought that escapes any mechanical explanation: he distinguishes between the mind and the body, evokes an "**oracle**" as a non-mechanical provider of mathematical intuitions, mentions the existence of **extra-sensorial perception** and affirms that a mind can distantly affect other minds and materiality. Far from considering Turing as a mystical thinker, this session will aim at showing that his theory of intelligence relies on the idea that human mind and brain are **open systems**, which have grown and progressed only thanks to **exterior perturbations**. His "scientific belief in reincarnation" also invites us to question the thesis of the independence of the sign-treatment device from the material in which it is capable of being achieved, as well as the issues raised by the possible embodiment of a logical machine into the physical nature.

Indeed, if Turing is essentially known as a mathematician, a logician and a cryptographer, he was also interested at the end of his life in **nature philosophy**. Whereas his first works focus on the notion of formal calculation and the role of intuition and ingenuity in the mathematical reasoning, his researches finally tried to explain the apparition of **biological forms** from undifferentiated subtracts. This evolution from mathematical formalism to the biological question of **morphogenesis** (going through informatics) invites us to reread Turing's researches through the development of a transversal problem common to the sciences of ideality and of nature: the one of the **relationship between the calculable and the non-calculable**, and to challenge his meditation about the "**beyond" of the determinism**, both at a formal and a physical levels. The objective of this session will be to overcome the classical cognitivist and computational interpretation of Alan Turing in order to rethink his works at the age of digital technologies and reticulated computers.

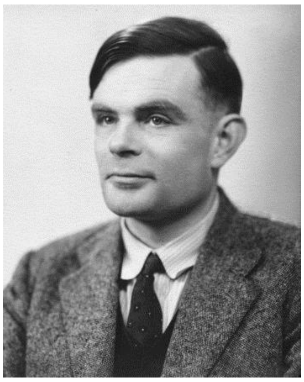
David Bates is a Professor of rhetoric at the University of California in Berkeley and the former director of the Center of New Media of Berkeley. His main research topics are the history of politics and legal thought and the history of sciences, technologies, media and cognition. During his previous lectures, he focused on the question of automaticity (http://enmi-conf.org/wp/enmi13/session-1/), on the one of the augmentation of intelligence (http://digital-studies.org/wp/david-bates-chapter-breakdownsummary/?lang=fr) as well as on the theory of flaw (http://enmi-conf.org/wp/enmi14/session-1/#video). He is currently writing *Human Insight: an Artificial History of Natural Intelligence*, a book in which he recounts the conceptions of human intelligence in modern science and aims at providing a critical history of artificial intelligence. This project begins with Descartes and the first ideas about the relationship between thought and machine, considers their transformations under the impact on technological evolutions and sciences of the body and nervous system, and results in a study of the digital and cybernetics.

Jean Lassègue is a sciences philosopher, Research Fellow at the CNRS, the EHESS and the Centre de Recherche en Epistémologie Appliquée of the Ecole Polytechnique (CREA). His works refer to philosophical anthropology and generally focus on the study of symbolic forms and activities: in this frame, he studied the emergence and evolution of informatics, both considered as a tool of modelization from an epistemological point of view, an anthropologic object which re-organizes knowledge and practices, and as a new step in the history of writing. In his book on Turing (*Turing*, Les Belles Lettres, 1998), he aims at describing the internal consistence of the whole work which progressively led the theoretician of artificial intelligence from mathematical formalism to the study of morphogenesis, going through informatics. His lecture during the Entretiens du Nouveau Monde Industriel 2014 focused on Turing, the algorithmic and the incalculable (http://enmi-conf.org/wp/enmi14/session-1/#video). This year, he publishes *Ernst Cassirer, du transcendantal au sémiotique*.

Jean Lassègue

Introduction

Jean Lassègue opened his lecture with a reflection on the title of the session, "reading Turing today". This immediately **hermeneutical title** indeed refers to the difficulty to think Turing's work after his "**canonization**" which happened last years, notably through the tribute of the British Prime Minister in 2009 and the forgiveness of the Queen, who regretted the chocking way Turing was treated. One is faced with a difficult situation, where the person of Turing appears as sacred and only one interpretation of his thought is allowed. But Jean Lassègue precisely seeks to criticize a certain part of this **official interpretation** which presents Turing's work as a limitless extension of the computational.

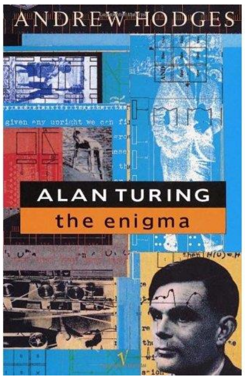


I – The constitution of a purely computational interpretation of Turing

Such an interpretation can especially be found in the work of the mathematician **Andrew Hodges**, of which one can trace three major steps:

1) [Andrew Hodges](), a British mathematician and Professor at Oxford, published in 1983 a book untitled ***Turing, the Enigma***. It is a wonderful biography of Turing, extremely rich and documented, which nevertheless mainly emphasizes the "Turing machine" and nearly neglects his work on morphogenesis in theoretical biology.
2) In 1988, Hodges publishes an article "**Alan Turing and the Turing Machine**", where he supports an interpretation about Turing's work: "Turing's thesis consists in saying that the model of the discrete state machine is the adequate description of a certain state of the material world, namely the brain".
3) In his 1997 work ***Turing, a Natural Philosopher***, Andrew Hodges develops the same interpretation and pushes it a little further, by trying to establish its historical veracity. "My hypothesis, Hodges writes, is that there was a turn around 1941. During this period, he abandoned the idea that the moments of intuition correspond to some incalculable". The field of calculable would then include all what the human brain can do, including creative processes. One witnesses an interpretation which sees Turing's work as a **progressive extension of the perimeter of calculable, also including the implicit and the original**, which would not be thought on the mode of non-calculable but on the one of a *forthcoming* rule. But the bias lies in the fact that Hodges does not justify his idea that according to Turing the rule would always be needed and, in the field of creation, would merely move from an implicit to an explicit state.

While recognizing the merits of Andrew Hodges' analysis, Jean Lassègue proposes another interpretation of Turing's work. For him, the question underlying all his intellectual journey is to know: how to circumscribe the perimeter of calculable? And the constant answer he gave all his life: we need to **extend maximally the scope of calculable, *one recognized* a logical frontier between the calculable and the incalculable** – and not, as Hodges says, to extend maximally the perimeter of calculable.



<u>II – How to circumscribe the field of the calculable?</u>

To support his analysis, Jean Lassègue displayed the three fundamental questions formulated by Turing in order to circumscribe the perimeter of the calculable:

1) What is meant by "calculation"?
2) What is computational in nature?
3) How to conceive what seems to escape any calculation?

1 – What is meant by calculation?

The first question is approached by the mathematical logical paper Turing published in **1936**, "On Computable Numbers, with an Application to the Entscheidungsproblem". While he was studying **Hilbert**'s program, Turing focused on the **decision problem** as posed by Hilbert. He wondered if, in formal axiomatics, not only the well-formed formulas but also the calculations on formulas would all be represented by numbers. Turing solved this Hilbert's problem with a negative answer: according to this paper, one cannot decide through calculation whether each number corresponds to a theorem calculable through formal axiomatics.

David Hilbert

Three consequences result from this 1936 article:

1) Turing's reader must have internalized the computational point of view;
2) There is not any beyond of the calculation in Turing's reasoning, only a **limitation**;
3) Nothing can positively be said about non-calculation: the non-calculable is a kind of ghost which only can be thought through calculation. One sees the establishment of a thought of the calculable which will be at the **basis of informatics**.

2 – What is computational in nature?

For Andrew Hodges, a **swing** in Turing's thought happened during the war, in so far as until 1941 he kept a (non-defined) place for the non-calculable; whereas after the war the question without being solved would no longer arise – as if the field of calculable was already enough.

But Jean Lassègue shows that in a **1939** paper untitled "Systems of Logic Based on Ordinals", Turing seeks to reduce to a minimum the role of intuition, knowing that is impossible to rule it absolutely out, since intuition refers to something that is not calculation. He distinguishes in this paper two faculties of mathematical thought, **ingenuity and intuition**, and shows that ingenuity possesses in itself a part of inaccessible, thus demonstrating that there is a part of inaccessible in what comes from the rule itself.

But from **1950** things get more complicated, when Turing progressively abandons theoretical informatics to focus on **theoretical biology** studies – a move that the canonical interpretation conveyed by Hodges did not follow enough. According to Andrew Hodges, the paper Turing published in 1950 ("Computing Machinery and Intelligence ", *Mind*, October 1950) aims at a kind of generalized extension of the calculable – but an attentive analysis of the text proves that this interpretation is unjustified.

Jean Lassègue explains Turing's "**imitation game**" as formulated in the 1950 paper: an interrogator is in front of two players, a man and a woman, and tries to find who the man is and who the woman is – i.e. to detect the maximal physical difference. The idea then was to replace the masculine player by a computer to know whether the interrogator would be able to identify if he deals with the same masculine player or with a machine. But the conclusion the game has to reach destroys the conditions of possibility of its own construction: the physical difference between the players has to be both forever undetectable and always presupposed so that the game can work. It means that the game is **undecidable** in the sense of the 1936 paper, or that the interrogator is a **maker of oracles**.

Turing's position thus is not as simple as we can think: it does not only aim at corroborating the idea that the simulation of human intelligence by informatics is possible. The introduction of an "oracle" refers to something that we could not think through the logic of calculation and seems to escape it: the purely computational approach is the not satisfying.

3 – How to conceive what seems to escape any calculation?

a) Gödel's interpretation of the Turing Machine

The answer to this last question especially challenges Hodges' interpretation. It implies an analysis of the **concept of form**.

Jean Lassègue revisits a remark formulated by **Kurt Gödel in 1933** about the formalism of the Turing Machine: the universal machine is the typical example of a machine of which the global behavior cannot be predicted in advance. Gödel writes: "In this case, one could say that the full description of its behavior is infinite", because it "could be given only by enumerating all instances". This text by Gödel shows two important points about the Turing Machine:

- The universal machine appears as an example of construction which exceeds the ingenuous and computational feature – it is really an **instance of intuition**;
- It also appears as an instance of the **halting problem**, since a certain number of computational processes are inaccessible through the means of calculation.

One thus faces the **absence of any possible schematization in the form of rules**, and the necessity to go through a **symbolization** of these behavioral forms.

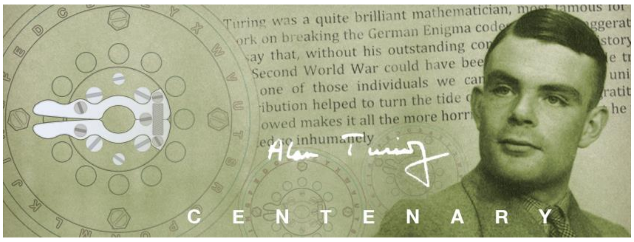
Kurt Gödel

b) <u>An epistemological debate between predictive and non-predictive determinism</u>

Turing's 1950 paper is, therefore, much more subtle than an informatics simulation of human intelligence. The author is not dupe of his comparison between the brain and the computer: the computer is a "**laplacian** **machine**" which falls into a **predictive determinism**; whereas the physical world in general does not correspond to a predictive determinism, since many phenomena, as pointed by Poincaré, have a chaotic behavior and belong to a **non-predictive determinism**.

Turing is also interested in the relationship between human and mechanical intelligence, by elevating the debate at an **epistemological** level about the relationship between predictive and non-predictive determinism –the superposition of these two kinds of determinisms being the very object of this 1950 paper. It also raises the question of the relationship between the calculable and the non-calculable – question that Turing explored during all his life, including in his work on theoretical biology. With this part of his work, one notices a transition from a notion of form in the sense of "**formal**" according to Hilbert's vocabulary, to a conception of forms in the sense of "**living in nature**", which represent some incalculable and raise the problem of morphogenesis.

The philosophical paper of 1950 tries to think the relationships between the **originality of the apparition of a concept** (the one of universal machine) and the **originality of the apparition of forms in nature**. And this is the very heart of the problem: how to considerate thought and nature as processes of progressive individuation of forms? The imitation game takes another turn: the paper consists in the description of the **individuation process of a form of thought** (the one of universal machine) and of the ambivalent relationship this form has with the two modalities of its possible embodiment: namely the programmable and the improgrammable.



Conclusion

It is now possible to retrace the fundamental issue of Turing's journey: from the 1936 paper, he establishes a distinction between calculable and non-calculable; and then he goes all along his life through different steps to consider how far the calculable can be extended, *knowing that* this calculable cannot be extended to the totality of reality. In 1952, Turing is convicted of homosexuality to a chemical castration which in all likelihood led to his suicide.

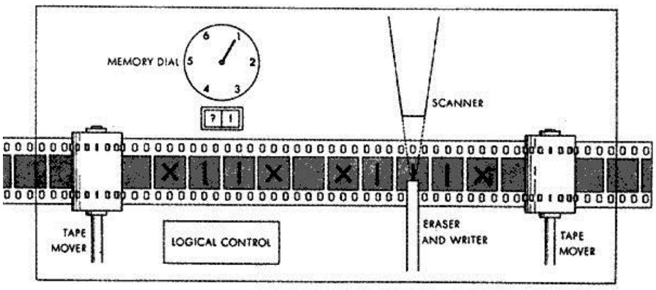
At the end of this study, one understands that Hodges' canonic interpretation is far from being sufficient. Andrew Hodges' hypothesis is that Turing moved from a "mechanical intelligence" (in the restricted sense of information) during the war, with Turing's decryption of German submarines, to a reflection about "human intelligence". But the general meaning of Turing's journey is much richer. For Lassègue, his work is also to interpret as the transition from the form in the sense of **formalism** to the form conceived as **form production**. Rereading Turing today therefore requires a critical exploration of this canonical interpretation.

David Bates

Beyond the mechanism of thought: Turing's notion of artificial intelligence

David Bates based his intervention on three different periods of Turing life and work, during which the theorist of artificial intelligence clearly states that human cognition escapes from any purely mechanical explanation, contrary to the cognitivist interpretation of his thesis. David Bates then discussed Turing's reflexions about the notion and construction of an intelligent machine.

In 1950, during the emergence of the new discipline of Artificial Intelligence, Alan Turing ventures the hypothesis that in 2000, digital computers will be able to simulate human cognition. In Artificial Intelligence history, this statement was retained as the idea that mind can be understood as a sort of machine, and can be modelled by a universal machine, the famous Turing machine. In fact cognitive sciences and neurology nowadays understand brain and mind as automated information processes (of the same type as computers).



a Turing machine

According to David Bates, this conclusion is a misinterpretation which is unaware of Turing intellectual project. Far from considering thought as a mechanical process which could be simulated by a machine, Turing's objective consists in the creation of intelligent machines. He analyses human intelligence in order to find a way to transform a simple machine into an intelligent one. What makes this project as much fascinating as problematic is the fact that Turing knows very well that the most interesting aspects of human intelligence exceed every mechanical comprehension.

I. <u>A non-mechanical conception of human intelligence</u>

1) The letter about the nature of spirit (1932)

In 1932, after the death of his best friend and first love, Christopher Morcom, Turing writes to his mother. He then believes in reincarnation and is inspired by quantum physics. He writes that the laplacian conception of a mechanical and predictable universe disappeared and he asks the question of the atoms arrangement. He states that matter without spirit would be meaningless and that living bodies attract and preserve spirit, which find a new body to « live in » when the first body dies. This letter is considered as an immature work by commentators, but one should remember that even in 1950, Turing acknowledges the fact that consciousness is a deep mystery.

2) Article on computable numbers (1938)

In an article on computable numbers, Turing maintains that computability can be understood as an automatic process produced by a machine or by the human mind, acting like a machine, that is to say, following rules. But Turing notes that in ambiguous situations, there is no more rule to follow: the machine stops and it starts again only if an external agent takes an arbitrary decision. From there, Turing develops the idea of an oracle which could be consulted by an automatic machine each time it has no more rule to follow. But according to Turing, this oracle could never itself be an absolutely determined machine.

In his Princeton thesis, Turing tries to distinguish between:

-purely formal or mechanical processes

-processes which implies a mathematical intuition

He wants to know if there are some spontaneous judgements which do not result from conscious reasoning. This oracle is a mathematical construction and not a psychological aptitude: Turing agrees with other mathematicians who insist on the ability of the mind to access to a specific form of truth unverifiable through formal systems. Turing is interested in the link between formal method on one side, and less formalisable ones on the other side.

3) Article on imitation game (1950)

In the article on « Computing Machinery and Intelligence », Turing thinks about the possible objections to the fact that a computer can be considered as a thinking being if it manages to make his interlocutor believe that it is itself human (Turing test's hypothesis). He states that the objection based on extra-sensorial perception must be taken seriously. Extra-sensorial perception can take four different forms: telepathy, clairvoyance, precognition, and psychokinesis.

Turing then imagines a second imitation game in which the computer competes with a telepathic. Commentators read this part of the text as an ironic passage, but David Bates reminds us that at this time, extra-sensorial perception was taken seriously by a lot of intellectuals, especially in Duke University of North Carolina, around professor J.B. Rhine. Moreover, Turing maintains that there exist a lot of proofs of telepathy, and he seems fascinated by the fact that thought can travel from a body to another.

J.-B. Rhine and L. Rhine

II. What is an intelligent machine ?

-Intelligent behaviour: a deviation from order and routine

These three sections show Turing interest's towards different ways of thinking which occurs during the usual and predictable functioning of corporal mechanisms. He does not look for a superior intelligence beyond the mechanical universe, but does not think that intelligence can be mechanically explained. He rather sees intelligence as a breaking force inside the machine itself. According to Turing, what is at stake in Artificial Intelligence is the creation of artificially intelligent machines. What is the meaning of such an idea?

In an article about intelligent computers written in 1950, Turing uses the word « intelligence » and « intelligent » only once:

-"intelligence" names the quality a man must have in order to command a machine

-"intelligent" behaviour consists in a slim deviation from a determined and calculable behaviour

But if a computer is a computable machine, what could be the basis of the deviation from the computing process? How a computer could stop to compute?

-A machine capable of transforming itself by breaking with its instructions

In a conference about the construction of a new automatic computable machine that Turing gave in 1947 in Manchester University, he maintains that programming consist in treating the computer as a slave: we give orders to the computer, thus preventing us from taking advantage of its potentiality. According to Turing, the establishment of an instructions' list is only a first step: the machine should be able to modify its instructions, in order to produce unpredictable new operations. The machine intelligence lies in its ability to break with its own instructions. The question then becomes: how to build a mechanism able to identify a good reason to transform itself and break with its instructions?

-Intelligence: the deviation form an order

The year after, in an article devoted to intelligent machinery, Turing relates the story of the mathematician Gauss, who resolved a mathematical problem without following rules, but by inventing a more efficient method in order to avoid a tedious calculation. This anecdote shows that for Turing, intelligence is a deviation from routine: it is the ability to deviate from well-known rules and to find new methods in front of the « undecidable ». This means that according to Turing, there is no mechanical intelligence. In this text, he bases himself on examples of non-organised machines, which seems to escape from the classic definition of the machine as a mean produced to achieve a defined end: the non-organised machines do not have a predetermined objective. But it is not the lack of organisation that leads to intelligence, but the ability to deviate from a routine order: intelligence is put in place thanks to shift and flaw of the machine itself, and not through an external intervention.

-The relation between discipline and initiative

An intelligent machine has to be disciplined as well as able to take initiatives. If it does not conform to the rules, something new happens: the machine has to acquire routines but also to take initiative, and such a power cannot be programmed in advance. But even if discipline is not sufficient to produce intelligence, Turing does not describe initiative as another ability of the machine. On the contrary, he maintains that initiative is the "residue" of discipline itself: something which remains, as an underlying state in routine behaviours. His aim is to discover the nature of this residue in human behaviour, in order to reproduce it inside the machines. In order to build an intelligent machine, one has to introduce discipline and initiation at the same time in a non-organised system.

III. Opening, indecision, interference and wandering

-The role of interference in an open system

A thinking machine develops itself form its primary condition of open system: in order to act, the human machine has to be exposed to lots of interferences. Interference is the rule: information enters the system from the outside, thus modifying the organisation of the machine and enabling it to develop new behaviours. The discipline of human mind (the set of rules and programs that we learn and appropriate) comes from the constant interference with a mind which is initially unorganised. Order comes after a first state of disorder. Human mind machinery is radically open, it is an indeterminate system. The cortex, which is the region of the brain associated with the most complex form of cognition, is also the least organised part of the brain, and does not have a defined function. Our cognitive behaviour implies an external interference: in order to become a thinking machine, a machine has to be open.

-Indecision as a crucial condition of intelligent behaviour

According to David Bates, this primary and fundamental indecision is the « residue » which always goes with the disciplined and cultivated individual: the cortex plasticity never disappears, from childhood to adulthood. This opening and non-determination makes initiative and decision possible. What is here at stake is the paradoxical relation between determination and non-determination, between organization and disorganization, between automation and plasticity.

-Risk, wandering and mistake: condition of invention and innovation

The intelligent machine is the machine which fails at being a perfect machine. Intelligence always implies a risk: it emerges in front of a new unpredictable situation. For the intelligent machine, infallibility is not an ideal, error is unavoidable when the machine is brought face to face to a new territory, without any available program. The crucial wandering which characterises human mind must be put into the machine, in order to enable it to transform its routine and to find new ways: wandering and mistaking are necessary to discover new methods. It is what Turing states in 1951, during a lecture devoted to the question of transforming a machine into a thinking machine.

Conclusion

Turing does not maintain that a machine can simulate human thought or that human thought is graspable through a set of rules and routines. On the contrary, according to Turing, a machine can become intelligent only if it is devised as an open system capable of determining itself by resisting to programing: the machine thus becomes able to open itself to new organisations and new routines.