

TRACES OF A COMPUTATIONAL MIND

FROM WAX TABLET TO TURING MACHINE

Massimiliano Lorenzo CAPPuccio

RÉSUMÉ : L'image de l'écriture est singulièrement fréquente dans des explications cognitivistes du fonctionnement de l'esprit, non seulement comme métaphore mais également comme paradigme conceptuel : la machine de Turing, en particulier, montre un isomorphisme structural complet avec l'utilisation de l'écriture alphabétique. La machine de Turing effectue exactement les mêmes opérations effectuées par un homme écrivant avec le stylo et le papier et cela dépend de deux raisons : 1. il a été conçu dans l'image et la similarité de la pratique concrète humaine de l'écriture ; 2. c'est le produit typique de la rationalité occidentale, dont le développement n'a été rendu possible que par les caractères spécifiques du traitement alphabétique de l'information. Ces aspects sont utiles pour comprendre la raison pour laquelle l'esprit a commencé à être dépeint comme machine d'écriture au moment même où l'alphabet a commencé à se diffuser : une recherche généalogique montrera comment, dans des traités de mnémotechniques et dans la métaphysique de Platon et d'Aristote, nous pouvons trouver la toute première base de chaque modèle logico-symbolique de l'esprit.

MOTS-CLÉS : machine de Turing, alphabet, cognitivisme, Platon, Aristote, généalogie, pratique, esprit.

ABSTRACT: The image of writing is singularly frequent in cognitivist explanations of the functioning of mind, not only as a metaphor but also as a conceptual paradigm : the Turing machine, particularly, displays a complete structural isomorphism with the use of alphabetical writing. The Turing machine performs exactly the same operations carried out by a man writing with pen and paper and this depends on two reasons : 1. it has been conceived in image and likeness of the human concrete practice of writing ; 2. it is the typical product of the western rationality, whose development has been made possible only by the specific features of the alphabetical treatment of information. This is useful to understand why the mind started being depicted as a writing machine just when the alphabet began spreading : a genealogical investigation will show how in mnemotechnics treatises and in Plato's and Aristotle's metaphysics we can find the very first foundation of every logico-symbolical model of mind.

KEYWORDS : The Turing machine, alphabet, cognitivism, Plato, Aristotle, genealogy, practice, mind.

ZUSAMMENFASSUNG : Das Bild der Schrift erscheint häufig bei erkenntnistheoretischen Erklärungen der Funktionsweise des menschlichen Geistes, und zwar nicht nur als Metapher, sondern auch als begriffliches Paradigma. Insbesondere besitzt die Turing-Maschine einen vollständigen strukturellen Isomorphismus mit dem Gebrauch der Buchstabenschrift. Die Turing-Maschine führt genau dieselben Operationen durch wie ein Mensch, der mit Stift und Papier schreibt, und zwar aus zwei Gründen : 1. sie wurde nach dem Vorbild des menschlichen Schreibens entwickelt und 2. sie ist ein typisches Erzeugnis des westlichen rationalen Denkens, dessen Entwicklung nur durch die Alphabetisierung der Information möglich geworden ist. Diese Gesichtspunkte sind hilfreich, und zu verstehen, warum man angefangen hat, den menschlichen Geist als eine Maschine zum Schreiben darzustellen, als die Verbreitung des Alphabets einsetzte. Eine genealogische Untersuchung wird zeigen, daß wir bereits in den mnemotechnischen Abhandlungen und in der Metaphysik von Plato und Aristoteles die ersten Grundlagen eines jeden logisch-symbolischen Modells des menschlichen Geistes finden können.

STICHWÖRTER : Turing-Maschine, Alphabet, Erkenntnistheorie, Platon, Aristoteles, Genealogie, Praxis, Geist.

RIASSUNTO : L'immagine della scrittura è singolarmente frequente all'interno dei modelli cognitivisti del funzionamento della mente, non solo come metafora ma anche come paradigma concettuale : la macchina di Turing, in particolare, esibisce un completo isomorfismo strutturale con la pratica dell'uso della scrittura alfabetica. La macchina di Turing esegue esattamente le stesse operazioni effettuate da un uomo che scrive con carta e penna e questo dipende da due motivi : 1. essa è stata concepita ad immagine e somiglianza della concreta pratica di scrittura umana ; 2. è il prodotto tipico della razionalità occidentale, il cui sviluppo è stato reso possibile specificamente dalle caratteristiche del trattamento alfabetico dell'informazione. Ciò risulta utile per comprendere perché la mente abbia iniziato ad essere raffigurata come un dispositivo di scrittura proprio quando l'alfabeto ha iniziato a diffondersi : una ricerca genealogica mostrerà come già all'interno degli antichi trattati di mnemotecnica e nella metafisica platonico-aristotelica sia possibile rinvenire la prima fondazione di ogni successivo modello logico-simbolico della mente.

PAROLE CHIAVE : Macchina di Turing, alfabeto, cognitivismo, Platone, Aristotele, genealogia, pratica, mente.

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PREMISES

References to writing systems in today's cognitivistic literature are so frequent that they could hardly go unnoticed and, looking back to historical theories of mind, things don't seem substantially different. Inside many authoritative treatises it is not unusual to find serious analogies between the functioning of cognitive structures and the gesture of inscribing letters on a sheet of paper : psychic processes are most of the time compared to graphical operations aiming to manipulate some kind of mental text.

This could hardly appear unsuspecting to who, like Jacques Derrida, refers to writing as a « metaphor obsessing European discourse », *i.e.* a metaphor constituting the symptom of the removal of an onto-theological metaphysics¹. Also the historian of psychology John Sutton, about these days most diffused models of mind, notices a « strange continuity in metaphor and model from ancient wax tablets [...]»² ; as to say, in other words, that since Plato and Aristotle every scheme of the biological functioning of mind kept a close relation with the basic paradigm of alphabetical writing³. This paper aims to start a genealogical investigation into the origin of the metaphor of writing in the field of discourse concerning mind, with special attention to computational cognitivism ; the theoretical and methodological frame of this work is evidently in debt with Carlo Sini's philosophy of writing and with his phenomenology of practices.

TURING AND THE MACHINE THAT THINKS WHILE WRITING

How does a mind work in the eyes of classical cognitivism ? Its functioning has been ironically synthesized by Daniel Dennet with the colorful image of the *walking encyclopedia*⁴ : a huge, incredibly complex text in which old information is stored as a sequence of symbols disposed in a rationally organized space ; this space is divided into *cognitive boxes*, so that when information enters one of them it is processed by the specific algorithms of that box ; the output information resulting from this process is supposed to express virtually

1. DERRIDA, 1967.

2. SUTTON, 1998.

3. About this problem, also connected with its social and political characterization, see CAPPUCCIO, 2002.

4. DENNET, 2001, p. 133-143.

any sensorial or intellectual faculty. Dennet claims this model is too similar to our daily commerce with the practice of manipulating written information through the media of pen and paper, and this is the reason why it shows its artificiality, appearing as nothing more than a curious « intellectual artifact ». If this claim is correct it would be imperative to understand how it could be culturally and scientifically possible that men started depicting the human mind itself as a device for manipulating information, and why this device is so suspiciously similar to the graphic instruments used by men to store information. Almost certainly the famous ideal machine developed by Alan Mathison Turing is the grandmother of every walking encyclopedia-like computational model of mind, as well as the main inspiration for materialist functionalism. Following this kind of consideration it wouldn't be difficult to show how the Turing machine, too, is nothing more than a mechanistic, automatistic, post-Gutenbergian representation of the practice of alphabetical writing daily used by the most part of western people. Obviously the Turing machine doesn't concretely perform the same activity of an individual writing a text on a sheet of paper : but it is quite easy to exhibit that a Turing machine executes, in a formally defined way, any basic logical operation that every man must carry out in order to compose an alphabetical text. First of all let's define what features characterize western writing :

(1) An alphabet is a writing system based on the engraving of a limited set of characters types ; (2) tokens of these characters can be repeated virtually infinitely, so that we can in principle imagine an endless sheet of paper carrying an endless text ; (3) characters are disposed linearly in a sequential way, so that only one character can follow the previous character ; (4) only a few combinations of characters are allowed, according to syntactic rules ; (5) syntactic rules don't depend in any way on the pictorial-representative value of single characters ; (6) syntactic rules are not dependent (6a) on the size of characters ; (6b) on any material and accidental qualities of characters, like color, style, physical medium, etc. ; (6c) on the time of persistence of physical realization of characters, before they are deleted or substituted ; (7) during the whole permanence of the physical character, the syntactic rules relating to it stay identical to themselves.

Please notice that if a writing system doesn't respect (5) it's an ideographic or logographic system, and that such a system (like mesopotamic cuneiform) could also not satisfy (6). Let us notice also that (7) defines from an operational perspective the principle of invariance of the pragmatic meaning of a symbolic expression (so we can say that, given some formally expressed syntactic rules, we observe a constant correspondence between each character and a fixed set of operations correspond constantly to each character).

Let us now verify if these features of the alphabetical writing are kept in Turing's famous model. By definition it's accepted that the instructions regulating the actions of the machine are determined by the machine's structure

itself ; syntactic rules are no more than *a priori* relations between input and output information, so that the Turing machine is just their « behavioral expression ». When referring to these rules we can maintain exactly the same assertions we maintained describing the western writing system :

(1) types of symbols manipulated by the machine are in a limited set ; (2) tokens of these symbols can be repeated virtually in an infinite way, because of the endless tape of the machine ; (3) because the tape of the machine is divided into equal squares, the disposition of these symbols can only be sequential and linear, and only one symbol can lie in a certain square at a certain moment ; (4) only a few determined operations can be performed by the moving head of the machine, according to built-in syntactic rules ; (5) the machine doesn't consider the iconic value of the computed symbols, and it is supposed to be unable to recognize any of their figurative features ; actually such a kind of recognition can only be performed by a calculator running a complex program based on a huge amount of elemental operations. In other words at the basic level of its functioning the machine will never recognize symbols for what they depict, but only for some abstract logical function they are related to ; (6) the machine can be virtually implemented on any physical support, and operate independently from material or accidental qualities of the characters ; (7) syntactic rules must be constant and always identical, otherwise the machine would react in some unpredictable way : this is assured by the fact that rules are built in the original structure of the machine.

At least from a formalistic perspective it seems like the essence of alphabetical writing and that of the Turing machine are the very same.

THE LOGICO-SYMBOLIC MACHINE AND ITS ALPHABETICAL SOUL

Since the publishing of his article « Computing machinery and intelligence⁵ », in 1950, Turing started defending an original and somehow scandalous thesis : not only his ideal machine is able to reproduce every algorithmic operation on the basis of simple recursive and mechanical operations with symbols, but in principle it must also be able to reproduce every cognitive activity of human thought, provided the truth of a second thesis which, correctly or not, has also been attributed to Turing : at a very elementary level human thought works exactly as a recursively operating machine.

At the same time another belief, even more surprising, began strengthening : if human beings think in a mechanical way then it's not at all impossible that one day machines will develop some sort of thought, provided they are sufficiently complex and powerful. Discussions about the correctness of these

5. TURING, 1950.

theses are barely speculative and it would be interesting to know what Turing himself would have thought about later interpretations of his claims ; it is sure, anyway, that since that time the Turing machine has been considered in many environments the main model to explain and comprehend the logical processes at the base of human cognitive functions.

But it would be useful to take a step back and clearly recall which epistemic and practical conditions and which intentional attitudes Turing's research concretely started from in the first place.

The Turing machine is capable of simulating some aspect of the human mind not because the human mind is objectively structured in a mechanical way, but because the machine itself originates from the same attitudes and the same postures every man needs to activate in order to think in a formally correct way. This brings up two consequences : (A) the concept of the Turing machine has been constituted imitating our practices of alphabetical writing and, even more important, (B) the Turing machine is the product of a specific conceptual frame which has developed and has found its meaning in an alphabetical conceptual frame, on the basis of the typically formalist and conventionalist exercise of alphabetical writing and reading.

Assertion A is testified by some consideration reported by Turing himself in his working papers, showing that he was aware of being inspired by a tangible human behavioral habit.

In fact, Turing adopted a very atypical method for a mathematician and considered at first the pragmatic observation of an anthropic element. In the following passages, extracted from his ingenious work of 1936⁶, Turing examines the work of a computer : let us notice Turing is not referring to the work of an artificial device here, but to the work of a man. Before the spread of calculating machines, actually, the word « computer » did simply mean « a computing person », using pen and paper for his calculi.

« It is always possible for the computer to break off from his work, to go away and forget all about it, and later to come back and go on with it. If he does this he must leave a note of instructions (written in some standard form) explaining how the work is to be continued. This note is the counterpart of the "state of mind". »

Also referring to the nature of instructions executed by the machine, Turing is clearly inspired by the human practice of alphabetical writing :

« Computing is normally done by writing certain symbols on paper. We may suppose this paper is divided into squares like a child's arithmetic book. In elementary arithmetic the two dimensional character of the paper is sometimes

6. TURING, 1936.

used. But such a use is always avoidable, and I think that it will be agreed that the two-dimensional character of paper is no essential of computation. I assume then that the computation is carried out on one-dimensional paper ; *i.e.* on a tape divided into squares. »

This helps to verify the first statement proposed above : the Turing machine is nothing more than the idealized, formalized, mechanized and put in an abstract space version of that concrete and living practice of alphabetical writing that brought up western rationality in the past 2 500 years. The Turing machine is an eidolon of alphabetical writing, and one of the most eminent.

Turing is partially right in expecting consensus from his reader : every western man would agree that two dimensions are more than enough for executing calculi, and for every person capable of reading Turing's diary it is ideally possible to imagine a purely linear, sequential system of symbols able to express every sort of computations. But could this appear so evident to a man ignoring the functioning of linear writing, *i.e.* a man unaware of the conceptual possibilities permitted by alphabet, like a mathematician of ancient Mesopotamia ?

This question leads to specifying the meaning of assertion B : also the idealizing, formalizing and abstracting conceptual habits making possible the constitution of a Turing machine are cultural products derived by the alphabetical mentality. The logic that structures the Turing machine is the same that Aristotle expresses in his formal logic, which was written in Greek characters and could not even be imagined in an ideographic writing system⁷ : first of all the principle of identity, that is at the very base of the recognition process of characters of the same type (and is, therefore, the fundamental notion for the functioning of every Turing machine), could constitute an admirable formal expression of the very first fundamentals of thought for an ancient Greek man ; but it could perhaps have been perceived as an obvious empirical triviality by a Mesopotamian scholar. The identity principle (that western people represent imposing a relation between letters, like « $A = A$ »), can't have the same value in an ideographic context and in an alphabetical one. Let us consider the example of reiteration : in an alphabetical context a sequence of identical letters (« aaaaa ») means that a reader will have to repeat five times the same operation (pronouncing the vocal « a »). Exactly like the moving head of a Turing machine, an alphabetical reader can't do anything else than executing the operations entrusted to written symbols, so that to every type of character corresponds exclusively one behavioral response : in the case of the alphabetical reader this response is the emission of a vocal sound ; in the case of a Turing machine an operation of movement/writing. For an ideographic reader nothing

7. SINI, 1989, p. 59.

could be more different, for every ideogram has the value of an icon and of an index : let's consider, for example, ancient Mesopotamian cuneiform inscriptions, where combinations of signs are not only linear and sequential, and utterances of the same logogram don't have the sense of a simple sum, but give place to different conceptual unities. For the logographic sensibility the last repeated character doesn't have the same meaning of the previous one, because different habits of response are related to the former and the latter : the attribution of an holistic structure of sense doesn't occur on operational bases but on iconic-representative ones⁸.

Recapitulating, it is possible to say that the Turing machine is two times a daughter of alphabetism : once because it has been conceptually built in the image and likeness of the writing/reading praxis, and once more because the same procedure of logical construction of the machine is nothing else than the formalizing conceptual procedure unique of alphabet. The Turing machine is the quintessence of alphabetism : as a copy of scriptorial practice and as the expression of a conceptual attitude.

IMITATED COMPUTERS IMITATING COMPUTERS

Once we become aware of the cultural and anthropological matrix the Turing machine arose from, it becomes necessary to radically reconsider the nature of that analogy, hypothesized by some part of cognitivism, between the logical thought of the human mind and logico-symbolical operations of the machine : even if this analogy is not unreasonable in itself, it can't in any case be inferred on an objective functional isomorphism between mind and machine, because this kind of foundation would assume as obvious just what has to be explained more clearly⁹.

Since the problem is what « computing » means for a man, it is not satisfactory to answer that « computing » means to operate recursively like a machine, because this obliges us to question what is the meaning of operating recursively

8. The semiotic fundaments of ideographic signification should certainly be explicated in a wider way. I assume the validity of Alfred Kallir's hypothesis about the « symbollic » value of iconic signs (see KALLIR, 1961), and its interpretation in Sini's thought (SINI, 1989).

9. Similarities between mind and machine don't occur because of some objective analogies in their structure, but because their concepts have been instituted in a mutual relation of imitation. Turing was at least partially aware of this difference conceiving its machine not as a model for the comprehension of human cognition but as the result of an *imitation game*. Actually the so called « Turing's test » was not meant to verify if a machine is objectively structured as a human mind, but only to furnish an indication of the coherence established between the behavioral response of the human and the machine playing this game. For a richer discussion of this theme refer to LONGO, 2002.

for the person that has built that machine or for the person whose machine is an imitation ; if we try to escape from this second question by answering that logico-symbolic operations performed by human mind are structurally analogous to the same operations performed by a machine, then the ghost of an absurd circularity appears.

It is possible to illustrate this circularity if we refer to the personal conceptual journey followed by Turing himself, by noticing how his work has been articulated in five stages : 1. first of all he began observing the behavior of a man working behind his desk, a man leaving notes to remind himself what he was doing, so that he could restart his job from the same point he left it ; 2. from these observations Turing abstracted a formal model of logico-symbolical activity, a model in which the written text on the sheet of paper is divided into equal squares or it is even reducible to a linear sequence of characters ; 3. exploiting this model Turing ideally built the prototype of a machine able to perform effective calculi in the shape of recursive and mechanical operations ; 4. observing the general ability of this prototype to simulate or reproduce human calculus, Turing hypothesized that the machine could be considered as an explicative and descriptive model for carrying out the main cognitive functions at an atomic level (and this will bring the British mathematician to anticipate the possibility that machines can think) ; 5. having foreseen that thought can be attributed to a machine, Turing imagined that the human mind is structured exactly like the ideal machine that bears his name.

At the end of this stage we come back again to stage 1 : the man sitting behind the desk and imitated by the Turing machine transformed himself, quite ironically, into just that machine. The circle is closed when the term « computer » transfigures itself and assumes a new meaning : the human computer becomes a mechanical – or electronic – computer. Turing accomplished an ingenious interpretative journey, being able to describe in automatistic terms calculus procedures performed by human beings. After that, having forgotten he set out his observations precisely from the anthropic element, he projected the just instituted truth back onto the epistemic conditions that permitted to institute this truth (or, in other words, on human nature)¹⁰. Turing's amnesia is neither premeditated nor merely accidental, but it is deeply-rooted in the

10. Turing's case is an eminent manifestation of a phenomenon studied by Maurice Merleau-Ponty and originally called by Henry Bergson « *mouvement rétrograde du vrai* », voir BERGSON, 1990. Synthesizing Bergson's argument we can say that every truth is established « here and now » by actual epistemic conditions, but it is immediately retroflected and collocated in history as an objective entity distant from the knowing subject and his context. This phenomenon displays how the context of the emergence of every science tends to disappear into the shadows of oblivion precisely when a positive history of that science is constituted.

epistemic and technological norm, which survives and reproduces itself constantly leaving in the darkness the practical conditions of its emergence.

The analogy between mind and machine can't be inferred on a functional or formalistic ground, as this procedure is evidently fabricated on a tautology and doesn't supply any tangible determination of the problem. In this perspective human thought would be explained on the ground of the machine's behavior, and the hypothetical thought of the machine would be assumed on the ground of human behavior¹¹.

Let us instead consider how profitable it can be to evaluate the analogy between human mind and machine in their cultural genesis, enlightened by a common practical and anthropological root : both human mind and machine are artifacts, inventions generated by a particular way of operating with signs, typical of western history.

MNEMOTECHNICS AND THE BIRTH OF THE ALPHABETICAL MIND

What is the origin of the metaphor of writing in the field of the science of mind ? Not casually western man started comparing mind to a writing device just when the first consonant-vocalic alphabetical system began imposing itself : in the Athens of the fifth century B.C., cradle of the explosion of the word-based civilization and field of the establishment of the first alphabet full of vocals¹². The idea that the mind functions as an information-storing support appears in mnemotechnics treatises at first. Simonides of Ceos, Hippias and the first sophists mastering this art, impressed by the huge amount of words that could be learnt by heart and indefinitely stored *in* the minds of those men following their training, started imagining the mind as a *tabula* (a writing tablet) divided into *loci* (or squares)¹³. In other words a malleable, spatially organized support able to keep and preserve written traces. But it is unrealistic to imagine that

11. It is here supposed that human behavior is the expression of a form of life, as already stated by Wittgenstein and even before – in different contexts – by Husserl, Heidegger, Dilthey and Nietzsche : a form of life intended as a polymorphic and irreducible complex of praxis incorporated in a cultural context and embodied in gestures, postures and creations of the human beings. If we state that a machine mimics human behavior it will be necessary to understand from which form of life the machine came. The affirmation that a machine lives an artificial life is not only counterintuitive but also unable to furnish concrete comprehension.

12. For what concerns the extraordinary cultural revolution initiated by the Greek alphabet refer to HAVELOCK, 1982. Alphabet not only impressed an acceleration to cultural, economical and legal development, but radically influenced the way of approaching the world at a very basilar cognitive level. About the influences of alphabet on cognition, with special reference to time-space perception, see DE KERCKHOVE, 1991.

13. About this see YATES, 1966.

sophists at first edified a theoretical prototype of mind imitating what writing concretely achieves, and that only later they started developing their art above this model of mind ; it is instead verisimilar that sophists, in practicing their art, at first began « engraving » words in their minds, exactly as they would have done with a wax tablet, and only later they started realizing that mind, whatever it really is, presents the same features of that tablet (like malleability and persistence). Mind as a wax tablet is not the result of a theoretical speculation, then, but results, so to speak, spontaneously from the exercise of certain praxis.

Only since the affirmation of two symmetrical techniques for memory storing – alphabetical writing and mnemotechnics – it has been possible to open a cultural receptacle such that the concept of mind could be seen as a logico-symbolical apparatus. Evidently before writing there was no mnemotechnics, and before mnemotechnics there could be not a mind structured according to alphabetical canons, as Turing intends it. Least of all could there be a mind able to express a logical and formal thought.

In *Theaetetus* Plato offers an evidence of this : Homer, says the founder of the Academy, conceived the heart – seat of memory – as a wax block modeled by a series of sensorial impressions¹⁴. But Homer, differently from Plato, was not aware that traces of sensorial impressions could constitute linguistic signs and certainly didn't ask himself if the correctness of a mental image does or does not depend on the logical and grammatical rules these signs are deployed with : in the age of sacral orality and of musically accompanied myth the mind could yet be conceived as something malleable and spatially organized, but the truth of correct discourse could not depend on the syntax of some linear sequences of symbols. This became possible only with the age of sophistry and Plato.

PLATO AND THE SYNTAX OF THE WAX TABLET

Plato would take one step further, an epochal step beyond sophistry. In one of his later dialogues, *Theaetetus*, the polymorphic complex of scriptorial practices of his age takes form in a huge metaphysical construction, able to complete the extraordinary institution of the psychic subject : for the first time it is not only supposed that soul is a completely immaterial, incorruptible entity, but also that it is a location where the world duplicates itself, occurring in the shape of an image ; a place, in other words, where sensible and intellectual realities are transcribed through a limited amount of signs indefinitely

14. PLATO, 1892, 194c.

repeatable. The psychic subject is then also a grammatological and alphabetical subject.

Plato, having already suggested in *Phaedrus* the existence of an intimate relationship between word and man, having compared a well structured discourse to the harmonic and symmetrical figure of the body, in *Theaetetus* he explicitly declares the textual nature of the psyche. With a very fortunate depiction he described how the thought is implemented in the living substrate of the human body :

« SOCRATES : I would have you imagine, then, that there exists in the mind of man a block of wax, which is of different sizes in different men ; harder, moister, and having more or less of purity in one than another, and in some of an intermediate quality.

« THEAETETUS : I see.

« SOCRATES : Let us say that this tablet is a gift of Memory, the mother of the Muses ; and that when we wish to remember anything which we have seen, or heard, or thought in our own minds, we hold the wax to the perceptions and thoughts, and in that material receive the impression of them as from the seal of a ring ; and that we remember and know what is imprinted as long as the image lasts ; but when the image is effaced, or cannot be taken, then we forget and do not know¹⁵. »

The meaning of this metaphor is perhaps evident to every man educated by the millenary tradition of the principle of *adequatio intellectus et rei* : every mental content exists just because it is immediately translated by a set of symbols somehow engraved on a hard support localized somewhere in the mind. This support is able to keep the impressions of virtually any symbols, and even symbols that are not actually impressed anyway lie in potency inside the formless matter. The capacity of carrying out reasoning or calculi is rooted in the ability of manipulating written signs in the soul : as explained by Plato¹⁶, in the case of an addition (7 + 5) the soul simply operates with numbers impressed in itself, exactly like a man would do with numbers written on a wax tablet. For the first time, at this point of the friendly conversation between Socrates and Theaetetus, western civilization caresses the idea that every mental event is a symbolic process.

Plato's dialectical science also deepens into the question about the grammatical rules controlling the use of symbols contained in the wax tablet : Plato is especially interested in elaborating an explication for cognitive errors¹⁷ (like

15. PLATO, 1892, 191c.

16. PLATO, 1892, 195e.

17. PLATO, 1892, 192a and later. Plato's discussion of the problem of cognitive error is surely more articulated than the simple synthesis presented here.

faked memory or misperceptions), aiming to clarify how information could be corrupted even if preserved on a stable medium. He will then clarify that cognitive error happens either at a syntactic level or at a semantic level : a syntactic error occurs when two symbols are associated in the wrong manner ; a semantic error occurs when symbols written in the soul can't be clearly associated with objects subsisting in external reality. None of them can in any way depend on a wrong application of the formal calculus procedure, but can only be related to a material imperfection, imputable to imperfect conditions of the physical support or to unfavorable material conditions of a perceptive process (like fog in the case of vision).

ARISTOTLE AND THE MIND AS FORM OF ALL FORMS

The implementation of soul within the human body is another highly problematic issue : if the wax tablet is localized within the soul then it is eternal and perfectly immaterial, and it is unclear how material imperfections can occur ; on the other hand, if the wax tablet is realized in some bodily structures, it is unclear how Platonic dualism can save the independence (and then the immortality) of soul, which would then depend on some physical substrate.

Aristotle did propose a solution of this problem, distinguishing a potential intellect (a passive physical realization of signs written on the tablet) and an active intellect (actively intervening by « enlightening » the written characters in consciousness-related processes). Quite similarly to the Turing machine, Aristotle's signs written in the soul are completely inert until they come under the attention of an active element : in Turing's model this element is represented by the moving head of the machine, able to identify the scanned symbols on the tape and somehow able to be so to say « directly aware ». The problem of the implementation of these two components will be formulated again and again during the whole history of western psychology, each time determining a different conception of the mind-body connection.

A considerable distance lies between the points of view of Plato and Aristotle : what was for the former only a verisimilar hypothesis inserted in a dialogical and narrative context, for the latter was an operative model of scientific explication. Let us consider what the Stagirite asserts in the treatise *De anima*¹⁸ :

« By a "sense" is meant what has the power of receiving into itself the sensible forms of things without the matter. This must be conceived of as taking place in the way in which a piece of wax takes on the impress of a signet-ring without

18. ARISTOTLE, 1984, book 2, sect. 12, 424a.

the iron or gold ; we say that what produces the impression is a signet of bronze or gold, but its particular metallic constitution makes no difference : in a similar way the sense is affected by what is coloured or flavoured or sounding, but it is indifferent what in each case the substance is ; what alone matters is what quality it has, *i.e.* in what ratio its constituents are combined. »

This concept is also expressed in the treatise *De memoria et reminiscencia*¹⁹, where Aristotle affirms that sensorial stimuli « involved the act of perception stamps in, as it were, a sort of impression of the percept, just as persons do who make an impression with a seal ».

This shape doesn't constitute a memory in itself, and actually « in so far as it is regarded in itself, it is only an object of contemplation, or a presentation ; but when considered as relative to something else, e.g. as its likeness, it is also a mnemonic token ».

In another part of *De anima*²⁰ it is asserted that not only perception but also potential intellect functions through a process of reception and impression of signs :

« Have not we already disposed of the difficulty about interaction involving a common element, when we said that mind is in a sense potentially whatever is thinkable, though actually it is nothing until it has thought ? What it thinks must be in it just as characters may be said to be on a writingtablet on which as yet nothing actually stands written : this is exactly what happens with mind. »

Certainly Aristotle didn't hold a computational vision of elementary cognitive processes and in general he did not conceive the carrying out of psychic processes as a series of combinations or as mechanical movements of simple parts (especially because soul is not composed of parts). Still it is possible to point out elements of radical innovation in his thought, elements which will remain until Turing's model. In other words we can say that, for Aristotle : (1) sensorial and intellective data are carried by psychic traces having the value of symbols ; (2) these symbols are present in consciousness as there is a relation of structural isomorphism between psychic traces and mental contents (so that configurations of traces correspond to configurations of mental events) ; (3) psychic traces are spatially and sequentially disposed : as time flows new traces are impressed beyond or above old traces of past mental events ; (4) this means psychic traces are discretely inscribed, because otherwise they would not be singularly recognizable ; (5) in the case of intellectual functions the symbolic flux is written on the potential intellect and read by the active intellect.

19. ARISTOTLE, 1931, sect. 1, 450a.

20. ARISTOTLE, 1984, book 3, sect. 4, 429b.

Concluding we could synthesize Aristotle's model this way : psychic processes are realized by discrete and sequential logico-symbolic operations of writing/reading ; they operate in space with information formally expressed through syntactically organized elements. It seems like Aristotle's model and Turing's are, under certain aspects, more similar than we could expect.

This model will find, especially since Galen, a complete integration into ancient physiology, and the nature of logico-symbolical signal will be made explicit in the anatomical theory of animal spirits, traveling along ventricula and being steadily impressed on the partitions of the heart. The aim of this paper, in any case, is to show the functionalistic and ilomorphistic perspective adopted by Aristotle. Let us notice again how sequences of symbols carry information only in virtue of their formal, quantitatively describable, structure : material realization of this structure is merely accidental and indifferent from a functionalist perspective. So that, not differently from Putnam's principle of multiple realizations²¹, a soul is virtually realizable with every material support.

The soul is defined by Aristotle as the formal cause of living bodies and at the same time it is the form of all forms : a logical space where every imaginable form can take its place and occur as a figure of thought.

THE LOGICO-SYMBOLIC STRUCTURE OF CONSCIOUSNESS

Like Anaxagoras, but differently from the rest of pre-Socratic tradition, Aristotle refuses the principle stating that a mind understands « similar through similar », because this presupposes a material and qualitative participation of some physical elements into cognitive processes : Empedocles, for instance, thinks that the flux of atoms of fire reaching the organs of sense is not only an expression of some perceptive information, but it is an embodied, qualitatively relevant, unity of sense.

Since Aristotle, on the contrary, western man began imagining that there is no material concoction between perceived objects and intellect : instead there is a mere impression of shapes. This can't be abandoned if we want to recognize the Aristotelian inheritance in modern conceptions of mind, and it is also an evidence that the Aristotelian model has been directly originated by an alphabetical cultural frame. For the Stagirite sensorial perceptions produced by the transmission of signals coming from sense organs and directed to the wax tablet of soul have nothing in common with any qualitative features of the distinct signals taken on their own, so that in the mind of a man we could not find any direct depiction of the object of his thought, nor could we find the qualities of the object of thought in the symbols written on the tablet of soul.

21. PUTNAM, 1975.

The meaning of thought doesn't lie in any single symbol written in the soul, but emerges as the holistic result of their combination. In this paradigm the correctness of mental representations does not depend on iconic values but on syntactic rules.

This treatment of information is exactly what alphabet made so ordinary for us : an alphabetically written word doesn't keep any pictorial-representative relation with the thing denoted by it. The writing system adopted by Athenians and by Romans prepared the European mentality for a merely conventional use of the graphic sign. That is why we take as given that a sequence of characters can be meaningful even if the original sacral value of the characters is completely forgotten, even if no character carries a meaning in itself, and finally even if this sequence of characters is completely decontextualized.

What pragmatic conditions permitted the alphabet to acquire such a special status ? By deploying in front of the reader the shape of represented objects, by displaying its vital and tangible features, ideographic and pictographic writing systems represent things in an intimate unity with their corresponding characters, so that reality is not only denoted but literally graphically embodied in written signs. On the contrary an alphabetical system, because of its desomatizing nature, conceals its own physicality and wrap itself with the intangibility of the voice : so that if letters can be used as merely conventional references to an operational praxis (the reading, the vocal gesture) it is just because alphabet hides its own iconic value.

Classical computationalism, with the theories of artificial intelligence, states that thought takes place in a series of computations : it appears difficult to falsify this statement and it is in principle also indemonstrable that thought is like a supplement added to the tangible body of some symbolic elements. The very nature of this problem appears destined to stay eternally unsolved if challenged in an abstract theory, and curious analogies between cognitive functions and the most different graphic tools will just remain mysterious coincidences²². It is perhaps the moment to start considering how it could be valuable to initiate a genealogical investigation concerned with the very origin of this problem and with the practical conditions of its emergence.

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(February 2003).

22. About the basic theoretical problems related to this kind of analogy, and specially to the epistemological dilemma of homunculus-like theories, refer to DRAAISMA, 2000, p. 212.

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