Chapter 1
OVERVIEW: FROM ARISTOTLE TO THE BITS OF AN INFORMATIONAL MIND

All Things Informational

How can anything, let alone the mind, be informational? At the time of writing (January 2012), it is estimated that more than 300 million people in the world use laptops or personal computers, of which about 50 million use the internet to access virtual worlds where virtual creatures can exist.\(^1\)

While a scientist may regard this activity in the perspective of how well the technology works, philosophers may perceive it differently, by questioning how the ‘existence’ of a virtual object differs from, or is similar to, the existence of a real object in the real world. Some even take an enormous leap by saying that the way virtual objects ‘exist’ in a computer can throw some light on how the mind exists in the brain.\(^2\)

In contrast, in this book, we intend the computer to take a backseat in such discussions. We do argue, however, that virtual objects can exist as states of neural networks and that such objects can have just as vivid a character as any virtual creature in a virtual world created by an artist/programmer. However, neural network and the cells of a living brain have been in existence even before the advent of the programmed creature, some of these virtual objects are simply called the thoughts of the living organism. They are certainly not put there by a programmer but they arise through the attrition of living or, put in a less tortuous way, by the process of building up experience by living.

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\(^2\) John Pollock, a philosopher at the University of Arizona, has written about this topic (see http://oscarhome.soc-sci.arizona.edu/ftp/PAPERS/Virtual-machines.pdf) as has the philosopher/computer scientist Aaron Sloman of the University of Birmingham in the UK (particularly ‘Virtual Machines in Philosophy, Engineering & Biology’ contributed to the 2008 Workshop on Philosophy and Engineering — See http://www.illigal.uiuc.edu/web/wpe/about/).
Aristotle's Laptop: The Discovery of Our Informational Mind

We are not the first to suggest that mind is a virtual object which emerges from a neural network. But what are virtual objects? What are they made of? The inevitable, but not immediately comprehensible, answer is that a virtual machine is informational. This book is an attempt to unravel and explain this somewhat curious postulate. How can anything be made of information? How reassuring is it to know that our minds might be informational?

Aristotle appears in the title of this chapter because, with unequaled clarity and persuasiveness, he has shaped philosophy and science in a way that has remained influential right up to the present. As he would not have known what is meant by ‘informational’, the reflection of his ideas into modern philosophy of mind might be a factor that makes some philosophers reluctant to consider the possibility of the mind being informational.

It was only 2,500 years later that the so-called information sciences began to encroach scientifically on the human domain of communication. That communication can be assessed in terms of bits and bytes, computers can have memory and computers can even have malfunctions through electronic viruses are facts that are fairly well known to anyone who owns a laptop or a PC. And yet, looking for the ‘mind’ of an informational machine may still appear to be breaking some basic scientific rules. This book attempts, in the humblest possible way, to suggest that, had Aristotle possessed a laptop, he himself might have bridged the gap.

Sadly, scientists and philosophers have somewhat parted company on the validity of an informational approach to the mind. Much heated debate lies in scientific claims that philosophy brings nothing verifiable into our knowledge. Similarly, the philosopher does not like some elements of scientific certainty, seeing it as a form of arrogance. The basis of the informational style of argument is, however, scientific. The fact that it raises philosophical questions of existence and mind heralds a tiny glimpse of hope that philosophy and science may unite in an attempt to make progress. There is a problem of language. Expressions of the theory of information are mathematical and sometimes incomprehensible to those who do not naturally warm to the language of mathematics. This book aims to remove some of these barriers by tracing how some of the principles of information science have come about and how they might be expressed simply.

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Overview: From Aristotle to the Bits of an Informational Mind

The cast of characters in this story certainly includes Aristotle but also many others. Information is a young science and, in this first chapter, those who created it make their first appearance and then reappear later in the book. One aim of the book is to show that the true meaning of ‘the age of information’ is not, as some will have us believe, that we are a species driven by satellite navigation from computer workstation to digital television, while speaking to our virtual agents on mobile phones. The ambition is to be positive and suggest that the age of information is a future age in which our own minds will be better understood through a common interest among philosophers, scientists and computer experts in all things informational.

What is Information?

Remembering that we live in the ‘information age’ and asking ‘what something is’ drives the fingers in a rush to an internet search engine. Why not? In the case of ‘What is information?’ a number of definitions can be found. Here are some examples:

1. ‘A message received and understood’
2. ‘Knowledge acquired through study or experience or instruction’
3. ‘A collection of facts from which conclusions may be drawn’
4. ‘A numerical measure of the uncertainty of an outcome’

The many answers are not a sign of differences of opinion among those who attempt a definition, but are more an indication that the word has multiple meanings. Floridi calls ‘information’ a notoriously polymorphic phenomenon and a polysemantic concept, i.e., a word with many aspects and meanings. Floridi’s philosophy analyses the multiplicity of these meanings by starting with a ‘well-formed’ datum which can have several characteristics: truth/falsehood, environmental (the height of a tree), instructional (being told how to do something) or factual (a state of affairs). Here we advocate for a more coherent analysis of the seeming diversity.

Taking the above list, consider ‘A message received and understood’. The mention of a ‘message’ implies that there must be an entity who or which (not to exclude machines) wishes to send a message. There must be

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Available at http://wordnet.princeton.edu/perl/webwn?s=information.

a recipient of the message who or which does the understanding! But what is it to understand something? How quickly does the first attempt to find a simple definition of information bump into a huge philosophical problem. How are things understood? Here is what British philosopher John Locke (1632–1704), said in the first paragraph of his celebrated three-volume opus, ‘An Essay Concerning Human Understanding’:

...An inquiry into the understanding, pleasant and useful. — Since it is the understanding that sets man above the rest of sensible beings, and gives him all the advantage and dominion which he has over them; it is certainly a subject, even for its nobleness, worth our labour to inquire into...

It is not the intention here to discuss Locke’s philosophy, but to begin to appreciate that definitions of information naturally lead to matters of the mind. Indeed, words like ‘knowledge’, ‘experience’ and ‘conclusions’, in the other definitions, imply some mental effort. But the link is vague. An attempt to describe it in an unambiguous way needs to be taken in small steps.

It may seem odd, but a good place to start looking at information as a scientific idea is the most obscure of the above definitions: ‘a numerical measure of the uncertainty of an outcome’. This definition refers to ideas which begin with the work in 1948 of a young engineer on the staff of the Bell Research Laboratories in the USA. He is Claude Elwood Shannon, (1916–2001).

Shannon and Crackly Telephone Lines and Minds

(Chapter 2. Shannon: The Reluctant Hero of the Information Age)

Claude Shannon is mostly associated with providing measurements and formulae that enable engineers to measure the efficiency of transmission media (telegraph lines, radio waves in space, etc.) But what has this to do with the mind? Shannon’s efforts to measure information is based on surprise. ‘The more one is surprised by a message or an experience, the

6First published in 1688, now available in the Wordsworth Classics of World Literature series.
more is the information gained’. We shall see that this fact alone allows us
to suggest hypotheses as to how mind develops.

It was a quiet and subtle revolution: no headlines, no media presenta-
tions and no fuss. But, in 1948, Claude Shannon’s formal definition of infor-
mation made it possible, for the first time, to make information appear to
be a utility like water or gas. Amounts of information became measurable
in ‘bits’ as did the quality and capacity of transmission media such as tele-
graph wires, radio waves or just the air that transmits the pressure waves
created by our voices. He made it possible to show why a crackly telephone
line transmits less information than a good one.

According to Lord Kelvin, the ability to measure is to have a science⁷:

\[\ldots\text{when you can measure what you are speaking about, and express it in numbers, you know something about it;}\text{ but when you cannot measure it,}\]
\[\ldots\text{you have scarcely in your thoughts advanced to the state of Science.}\]

Measuring information in bits or bytes (chunks of 8 bits) is second nature
now: words like ‘broadband’, ‘hi-fi’ and ‘megabytes per second’ are famil-
liar to anyone who owns a computer, a music system or a smart mobile
phone. Even those who are not totally sure what such quantities mean are
prepared to pay more for more ‘megabytes per second’ in their internet con-
nection, knowing that it will enable them to download their movies more
swiftly.

In defining a measurable quantity, information, Shannon has also
spawned an underlying science called Information Theory. Engineers who
design contemporary commodities such as the internet, cellular networks for
mobile phones and global positioning systems (GPS) would be lost without
this theory. But where does this leave the philosophical difficulties about
‘understanding’? It is clear that Shannon found the idea of ‘meaning’ dif-
ficult, driving him to address deliberately the medium for carrying the
meaning and not the actual message. Unless the medium has enough carrier
capacity, the meaning will not be conveyed. So he wanted to measure
amounts of information as a carrier for meaning for the purpose of trans-
mitting as much of it as possible. Such capacity can be restricted by, for
example, low ‘fidelity’ and interference from electrical ‘noise’ which are the
chief enemies of good communication. He wrote clearly about concentrating

⁷Lord Kelvin (Sir William Thompson): *Popular Lectures and Addresses*
(1891–1894, 3 volumes).
on the carrying medium and avoiding the (semantic) issues of the meaning of information in the second paragraph of his ‘A Mathematical Theory of Communication’:

The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point. Frequently, the messages have meaning; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem.

(Shannon, 1948).

This statement led to some disagreement among communication engineers, some of whom did want to capture meaning in their system of measurement, and how this can be done is the subject of much of the book. But staying with quantity of information for now, Shannon’s genius lies in his realization that no matter what information is being transmitted it can be measured in ‘bits’ (binary units). A bit is a choice of two values. Morse code is a good example: dit and daat, also called ‘dot’ and ‘dash’, being the two values. So dit dit dit daat daat daat dit dit dit is decoded by Morse coders as SOS — Save our Souls. Given enough time and a known code any message can be transmitted. So when that which is being transmitted is music it can be coded into groups of bits which, if transmitted fast enough, can be decoded to produce energy bursts that drive the earphones or the blaster loudspeakers that are now so familiar.

The enemies of efficient transmission of bits in a medium are the limited ‘bandwidth’ of the connection and the amount of ‘noise’ it contains. The idea of limited bandwidth is familiar to those who listen to recorded music — the higher frequencies of sounds and the very low frequencies tend not to come through as clearly as the middle range. This is true not only of sounds but of all media that transmit information and, for instance, applies also to radio waves that travel through free space and to other forms of transmission such as via cables. The bandwidth of a medium is the range of frequencies it can carry. Because particles rush about at random in these media, there is interference with the transmitted signals, called noise. So some of the bits or groups of bits of information traveling in these media can be corrupted by noise or hindered by the lack of bandwidth.

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Shannon did one wonderful thing in the face of these deterrents to proper transmission. He developed a formula that allowed the designers of transmission systems to look around for codes that can get the maximum possible transmission of information across a medium despite a given unavoidable amount of noise and with a given limited bandwidth. But that is not the limit of his genius. He also showed how networks of switches may be analysed using the notation of propositional logic. This can be applied to networks of neurons too. More is said of this below. Here, it is important to nail down the appearance of Shannon information theories even at the level at which neurons transmit information to one another. We shall see (in Chapter 6) that this leads to hypotheses as to how and when consciousness might arise in a neural network.

Why Billions of Cells?

(Chapter 3. Billions of Brain Cells: Guesses and Models)

The study of the role that the material of our brains plays in our conscious sensations has had a rough historical ride. Aristotle assigned a ‘minor importance’ to the brain and wrote that the ‘the seat of the soul ... and nervous function ... is to be sought in the heart’. Notoriously, Descartes laid the foundations for dualism by appealing to the pineal gland as a link between ventricles — where the non-material matter of the mind resides — and the muscular behavior of the body. Now we know that the pineal gland secretes melatonin which helps us with jet lag and that the ventricles contain cerebrospinal fluid which cushions our brains against physical shock.

It was Schwann and Schleiden (1847) who, noting that most growing biological objects were made of cells, identified a varied and dense cellular structure in the brain. But, rather than throwing light on how brains function, this created confusion by initiating a major division of opinion. There were the reticularists, who effectively said ‘so what?’ to the brain being cellular. The fact that the liver and one’s big toe are cellular does not explain what they do and how they do it. Then there were the

9 De motu anima, published in the fourth century BC.
neuronists, who suspected that the cells (neurons, by then) were not passive, but contributed en masse to some complex function of the brain. The Nobel Prize committee felt that the cellular notion was important and awarded the 1837 Prize for Physiology and Medicine to neuronist Johannes Evangeliste Purkinje for his exquisite work on the cells and seemingly purposeful structure of the cerebellum. But then they hedged their bets in 1906 by awarding a shared prize to reticularist Camillo Golgi, for his most revealing staining techniques, and neuronist Santiago Ramón y Cajal for his detailed microscopic taxonomy of a variety of cell types and structures. By then, the neuronists were beginning to win, and the importance of discovering what the billions of cells in the brain are doing grew as evidenced by more Nobel prizes. In 1932, Charles Sherrington was given the prize for his discovery that the link between the output (axon) of one neuron and an input of another, the synapse, was not only variable, but also controllable by the chemical product (neuromodulator) of other neurons. And as recently as 1963, Lloyd Hodgkin and Andrew Huxley won the prize for discovering how the axon of a neuron generates pulse codes. By then, Shannon’s theory of information had been well established and it became clear that the stuff that neurons trade between them is informational.

In the meantime, Warren McCulloch and Walter Pitts (1943) published their seminal paper on the logical nature of the neuron and its synapses, with an immediate link to Shannon’s propositional logic formulation of switching circuits. Is the brain a massive switching circuit? Does something beyond the McCulloch and Pitts formulation emerge when spiking is included in models? While these questions were and still may be arduously debated, we feel that whatever the answers may be, they are incomplete without the next bit of history.

The Circles of the Mind

(Chapter 4. Imagination in the Circles of a Network)

With the model of a neuron as a decision element, the scientific world fell into a deep error. It jumped to the conclusions that the brain, being bombarded by sensory information, reacts to this through its progressive logical decision-making across intricate neural nets which adapt to provide the right responses. Known as the stimulus–response philosophy, this squeezes out the possibility of sustained thought and memory which we know can happen even without stimuli. Memory was thought to be
somehow sited in the progress of the activity from stimulus to response. It was the US zoologist-turned-psychologist Karl Lashley who strove to destroy this notion since it did not quite agree with his observations that even severe lesions sometimes only cause *gradual* degradations in a person’s ability to think, suggesting that some mass activity of neurons with some redundancy is at work.

Together with his student, Donald Hebb, he formulated the hypothesis that thought depends on inner, circular paths in neural tissue that might provide a potential home for the informational mind. In 1956, this gave impetus to what became called *automata studies* by none other than Claude Shannon, with a young colleague called John McCarthy (yes, one of the grandfathers of artificial intelligence). They organized a meeting which put in place some fundamental models and analyses of machines with automata. Some major figures contributed to the proceedings. S. C. Kleene (1909–1994) advanced a theory of input events that would lead to an ‘acceptor state’ that indicated that some structural rules were obeyed by the sequence of events. This was particularly useful in the design of automata that check the parsing of languages. And E. F. Moore (1925–2003) introduced ‘state structures’ which represent the complete function of an automaton. This has a very useful graphical representation which is often used in the book.

In 1956, Shannon and McCarthy expressed the belief that an understanding of networks and machines with internal states, through a proper mathematical formulation, is crucial to an eventual understanding of the mind. This promise did not materialize, and state machines were only used in the odd program, sometimes for the parsing of language. When it comes to ‘informational minds’, we believe that an understanding and deployment of automata theory is crucial. But even given automata theory and state structures, something is still missing. The states of an informational mind do not inform only through having a state structure: being conscious demands that the states themselves be somehow ‘felt’ — they should be ‘phenomenal’, as overviewed next.

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11 An automaton is a system with an internal state that is a function not only of the current input but also of the past history of such inputs.
12 It was during the writing of this book that we sadly heard of the death of John McCarthy on October 24, 2011.
13 One of the pioneers of theoretical computer science, known for ‘recursive functions’.
Phenomenal States

(Chapter 5. Phenomenal Information: The World and Neural States)

When our eyes are open, whatever mental states there might be are about what we would describe as ‘that which we see’. But when we close our eyes, removing that which is being seen, our mental states continue to be about something. It cannot be denied that what is being seen in the ‘mind’s eye’ is not only about things in the real world, but has an affinity with what was once seen. The ‘aboutness’ of mental states is the essential feature of a movement in philosophy: phenomenology. German philosopher Franz Brentano (1838–1917) called this aboutness ‘intentionality’. His student Edmund Husserl (1859–1938) initiated the phenomenology movement which is a philosophy that starts with a reality based on what the inner sensations of the world are like, and recognizes that this can be the only reality for the thinker. While Husserl might not have had views on the neural support for such a reality, in our own work we have been intrigued by the question of how an automaton might have reality-based states which we call phenomenal. We note that for such states to be useful, this inner reality cannot be at odds with world reality — this would not be good for survival. Imagine if an apple in position X were to give rise to our seeing it in position Y, or if the trigger for our seeing an apple were to be a rock. The observer would be misled and would end up undernourished.

There is also the possibility that the inner state of an automaton could be a pattern that uniquely encodes the external event. We reject this possibility, since, when faced with the alternative of a useful internal state coding, that is, one that contains the information needed for the organism to behave in a purposeful way, it is unlikely that evolution would have chosen the former.

For some years, since 1968 to be precise, we have been experimenting with something called ‘iconic learning’, and a formal description of this was published. Iconic learning is a simplified-world way of creating states that accord with input. Let there be a specific point (pixel) in the input image we label \(a\). Iconic learning devotes a neuron to this point which at any moment learns to output the value of input \(a\) for an input vector which

samples many points in the input image. The effect of this is for the state of the network to be a copy of its input image.

In this book, we describe a series of experiments with neural automata to show that phenomenal representations are not achieved ‘by any old neural net’, but require a subtle set of parameters (neuron size, with respect to net size, ratio of feedback versus input connections, etc.) in order for the phenomenal representations to be formed. This is as a background to the next, more recent, development in the saga of the informational mind.

**Information Integration**

*(Chapter 6. Information Integration: The Key to Consciousness?)*

The notion that phenomenal states, i.e., conscious states, may depend on subtle properties of neural networks came to the fore with a vengeance over the last decade or so years. Here is a quote from Tononi:\(^{15}\)

...to the extent that a mechanism is capable of generating integrated information, no matter whether it is organic or not, whether it is built of neurons or silicon chips, and independent of its ability to report, it will have consciousness.

This is a remarkable claim. Is it really true (as Tononi suggests) that the formal basis for the system support of consciousness has been tracked down to something called ‘integrated’ information? Later,\(^{16}\) we explain two forms of this theory, one based on effective information transmitted across boundaries within the network, and the other based on the information involved in state transitions. A pleasing and useful element of this work is the introspective judgment that mental states are *unique*, in the sense that each generates information with respect to the others, and that they are also *indivisible*, which means that the nets that carry them must be capable of representing causal relationships within the state.

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\(^{16}\)Using the work of two colleagues, David Gamez and Michael Beaton funded by the Association for Information Technology Trust to look into the importance of this area.
This is a helpful way of characterizing a mental state. It bridges from the introspective hunch to a physical requirement of a network. These two properties spell out what is meant by integration, and Tononi defines a parameter $\Phi$ to indicate how well a network integrates. The higher the $\Phi$ of the network, the better the network is able to produce mental states. So the high $\Phi$ areas of the brain are where consciousness is likely to reside. Now comes the first problem. Even in very simple networks, it is very difficult to measure $\Phi$. This is because it requires the use of all possible partitions and a calculation of $\Phi$ for each one of them. The worst offender, the partition with the lowest $\Phi$, determines the $\Phi$ for the whole network. In the book we describe an alternative way of measuring the capacity for integration based on the ‘liveliness’ of neurons. Liveliness, in a few words, is the probability that a neuron will transmit a change from one of its synapses to the axon. This produces a faster assessment of a kind of integration — not the same as Tononi’s but one that again indicates the ability of a network to have unique and indivisible states.

But there is a second problem. Information integration theory lacks a discussion of how states become related to reality. Tononi’s suggestion is that qualia (the phenomenal nature of inner states) may be characterized by identifying a geometrical structure composed of vectors of informational transactions of progressively more complex groups of interacting neuron. While this provides interesting polyhedrons that Tononi suggests are a representation of the qualia of a network, we allow ourselves the luxury of disagreeing with this. We go on to take a closer look at how visual representations of the reality of the visual world might occur in a simplified model of the visual system. The support of qualia may be much more obvious than the sight of intricate polyhedrons.

The Joy of Seeing

*(Chapter 7. The Joy of Seeing: Gathering Visual Information)*

When tired of too much theorizing with abstract models, it is always healthy to touch ground with the elements of nature, in this case those that exhibit puzzling sensations such as mental images. In the book we review the meticulous work of Semir Zeki$^{17}$ in studying the anatomy of the visual system.

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and how its function depends on this anatomy. He particularly addresses the fact that a considerable amount of specialization occurs in different parts of the visual system. For example, changes in color in the visual world cause activity in one part of the visual cortex, while motion or changes in shape do so in another. This leaves Zeki and his readers intrigued by how this disparate activity leads to the ‘precise spatiotemporal registration’ that is associated with the joys of seeing. We draw on our own work\textsuperscript{18} on ‘depiction’ to suggest an important integrating factor — muscular activity. We postulate that signals from the muscles serve to index the selection of neurons according to where in the world the attention is focused. We show with a simple model how the image from the fovea (a tiny central area of the retina) when combined with eye movement information can ‘paint’ a high acuity image of the world.

From this, we go on to speculate how not only motion and perceptual signals but also time might be integrated. We conclude that the state structure of the informational mind is an unending stream of unique and indivisible states which becomes lodged, but with a lesser precision than in the original perception, in what we call memory. We back this up with some simulation experiments which again show that the choice of network parameters (integration, indeed) strongly determines whether this mental state structure is a reasonable representation of our visual experience as aided by our ability to interact with and explore the world.

Some Don’t Like This

(Chapter 8: The Informational Mind: Oxymoron or New Science?)

Not all modern thinkers who worry about the nature of mind feel reassured by or even in mild agreement with the assertion that the mind is somehow informational. We set out not to conduct an adversarial battle over this issue but to understand their objections and then allow such objections to drive us into being clearer about what we mean by ‘an informational mind’ and sharpen up the concept.

We review the contention by philosopher and gerontologist Raymond Tallis (2004) that ‘the mind is not a computer’ and that the inclusion of information in discussions of brain and mind is responsible for creating a huge confusion in such discussions. But Tallis’ real quarrel is with Patricia Churchland’s ‘neurophilosophy’ (Churchland, 1986). This was published in the early days of the revival of ‘connectionism’ and mainly concerned itself with multi-layer recognition of image-like data. Tallis is therefore quite right that the mind can neither be reduced to the base level of information processing in a computer (some might call it the ‘machine level’) nor to successive ‘recognitions’ in the neural layers of the brain. In our approach the mind is informational because of the nature of the internal states which are the result of a subtle dynamic behavior of the net in response to ‘stimuli’.

Synapse expert Susan Greenfield objects to relying on information gleaned by someone using the internet. It concerns her that this could lead to a solipsism that curtails a young person’s ability to discover information by social interaction and science (see Swain, 2011). She fears that this will irrevocably alter the youngster’s mind. We argue in the book that, whatever informational models there may be of curiosity (e.g. Kelly, 1955), if youngsters are normal to start with, they are unlikely to show a malfunction because information happens to be easy to get.

Luciano Floridi (2010) is a prime motivator in the Philosophy of Information. A classically trained philosopher, he promulgates data as the focus for informational science in an attempt to concentrate on semantic rather syntactic issues. This appears to have two characteristic inspirations: data as it is commonly processed in a computer, and the linguistic representation of world events. This contrasts with our approach which is driven by the way that information creates our minds, and may not be ‘well-formed’ like the

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Data in a computer but may say something about the minds of living entities including those that do not use language. So perhaps Floridi’s models and our own do not contradict one another but merely represent information as formalized for machine processing in the former case, or as sculpted by our neural apparatus in the latter.

Another skeptic is the recently deceased Theodore Roszak (1933–2011). He flourished in the 1960s when looking at the threats to a sustainable social culture in general and due to information in particular (Roszak, 1986). He was concerned by the amount of power the word ‘information’ added to phrases such as ‘the information economy’ or ‘the information society’. His concern, which is easy to share, was that ‘information’ as it is crunched by a computer may be mistaken for the ‘ideas’ with which humans live in the world. Even more frightening is the thought that large corporations see themselves as controlling information sources and methods of dissemination. This, he felt, would degrade the value of ideas with respect to information simply because the latter have greater economic potential in corporations and the military than the former. An aim of this book has been to show that ideas are not excluded by a scientific understanding of the mind, nor are they likely to be missing from artificial machinery with mind-like properties.

A contemporary philosopher with a truly questioning outlook on information is Riccardo Manzotti of the Free University of Language and Communication in Milan. Sometimes he expresses himself in self-drawn cartoons, one of which is called ‘Where and when is information?’ Using the example of a the message ‘help’ written on a piece of paper, put into a bottle and tossed from a desert island to be picked up by someone unknown, he concludes as follows. Information is a process spread in time and space: it is with the sender of the bottle, the sea, the bottle, the paper and, later, with some recipient. ‘Informational minds’ could indeed be seen as parts of a process which forms bridges between many such minds and the elements of an external world. If one takes any one of these items in isolation it will not reveal a compete model of the entire process. Much more work needs to be done on this inspiration. So the material in the book could be seen

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25 To be published in the APA newsletter on Philosophy and Computers — details to be announced. Manzotti can be contacted at ⟨Riccardo.manzotti@iulm.it⟩
as asking how it is that a neutrally supported mind can take part in such a widespread process.

The Dark Submerged Layers of the Mind

*(Chapter 9. The Unconscious Mind: Freud’s Influential Vision)*

Here we have suggested that a mathematical treatment of the informational mind yields a structure of iconic states that exist by virtue of their accessibility. That is, if the world presents sensory stimuli to an individual, new states are created, but also old ones can be evoked. This structure forms our memory which is at work both during perception and in the absence of it. But historically, the mind was a dark and inaccessible place: a possible home for the spirits of madness, the humors of malevolence or the infestations of evils. Could such horrors be generated by the processes of iconic creation of mental state structures? We will explore how the iconic method can, indeed, create inaccessible states in the state structure. That is, states can be created which, with further growth of the state structure, can lose their links to the rest of the structure. Sometimes this is due just to lack of usage but at other times it may be because entry into those states has had an adverse effect and was purposefully avoided. It is intriguing to realize how close Sigmund Freud’s ideas of unconscious areas of the mind and the role of repression are to the isolation of states that can occur during the growth of the state structures of an automaton. In the book we examine these similarities and discuss the process of psychoanalysis that Freud used to restore access to the hidden states.

And Now For Aristotle

*(Chapter 10. Aristotle’s Living Soul)*

We end the book by taking a closer look at Aristotle’s *De Anima* — his scheme for defining the ‘form’ of the matter of the body as that which causes ‘being alive’. Written by a mature Aristotle with as much wisdom as he could muster, he found considering this ‘soul’ to be ‘one of the most difficult things in the world’. Such form defines the ‘livingness’ of living creatures. It contains a perception of the world, the capacity for nourishment and the
mind. The mind of humans is particularly able as it can ‘understand’ the form of other minds.

The key mystery is how the mind of an individual can be sensitive to the ‘form’ of another, which it clearly is. This is the basis for believing that the sciences, concerned as they are with the ‘matter’ of a living organism, will not be successful in addressing ‘form’ and an interaction between forms. Explaining the mind in terms of science is for Aristotle as fruitless as trying to use physics to explain what properties of bronze make a bronze statue of Hermes capable of honoring the god. How familiar this all sounds, and how powerful a proof is ‘de Anima’ of the influence of Aristotle on basic philosophical beliefs which one finds today not only among philosophers, but also as part of general culture. Such an inheritance not only concerns Aristotle’s clear explanations, but also some of his perplexity, which makes him declare that this is the most difficult of topics. We review how in this book we have tried to reduce some of this perplexity by introducing the science of information which, we argue, has much more to do with form than with matter. We imagine meeting Aristotle in an attempt to introduce him to the information sciences, but only find him in his dying moments. Are we too late?