A RETROSPECTIVE

回顾

The Complete and Final Theory of
Rational Human Intelligence as a Theory of Physics
With Its Own Mathematics

人类推理智能的终结理论——一个物理学及其数学的理论

1. Design(s) of the Present Book

The main design of the present book is to reprint—and thus facilitate access to—five articles published in two of the journals published by Scientific Research Publishing (SCIRP), more specifically four articles that appeared in *Advances in Pure Mathematics* and one that appeared in the *International Journal of Intelligence Science*. In these articles, certain preliminary reflections on the nature of rational human intelligence have been presented. My ultimate aim is to describe all of rational human intelligence. But it seemed good to take stock of where this whole effort is now at by uniting what has been done so far.

The five published articles in question are as follows:

1) "The Monty Hall Problem and Beyond: Digital-Mathematical and Cognitive Analysis in Boole's Algebra, Including an Extension and Generalization to Related Cases," *Advances in Pure Mathematics* (www.scirp.org/journal/apm; doi:10.4236/apm.2011.14027), Vol. 1, No. 4 (2011), pp. 136-154.

2) "Higher Variations of the Monty Hall Problem (3.0, 4.0) and Empirical Definition of the Phenomenon of Mathematics, in Boole's Footsteps, as Something the Brain Does," with an appendix by Richard D. Gill, *Advances in Pure Mathematics* (www.scirp.org/journal/apm; doi:10.4236/apm.2012.24034), Vol. 2, No. 4 (2012), pp. 243-273.

3) "To Comma or Not to Comma: The Mathematics of the Relative Clause, All Types, via Boole and Venn," *International Journal of Intelligence Science* (www.scirp.org/journal/ijis; doi:104236/ijis.2012.24015), Vol. 2, No. 4 (2012), pp. 106-114.

4) "The Mathematical and Physical Theory of Rational Human Intelligence: Complete Empirical-Digital Properties; Full Electrochemical-Mechanical Model (Part I: Mathematical Foundations)," *Advances in Pure Mathematics* (www.scirp.org/journal/apm; doi:10.4236/apm.2013.35071), Vol. 3, No. 5 (2013), pp. 491-561.

The following typos found in this article have been corrected in the present reprint of the article as Chapter 4 (references are to page, *column*, and line of the original article): (506, *a*, 11) for "or modern" read "of modern"; (513, *a*, 30) for "chose" read

"choose"; (515, *a*, 10 counting from bottom) for "and" read "an"; (546, *b*, 19) for "incrase" read "increase"; (552, *b*, 30) for "describe" read "described"; (553, *a*, 3) for "below" read "in later articles"; (554, *a*, 34) for "Maxwell's" read "Maxwell"; (555, *b*, 37) for "interested" read "interest"; (559, *a*, note 14, 1) for "P. E. B. Jourdain" read "Ph. E. B. Jourdain"; (559, *b*, note 67, 3) for "easily to locate" read "easy to locate". These typos, found in article 4), were first reported in article 5) cited below, at p. 463 n. 5. This report in article 5) has now been removed from the reprint of article 5) as Chapter 5 of the present book.

5) "The Prime Sequence: Demonstrably Highly Organized While Also Opaque and Incomputable—with Remarks on Riemann's Hypothesis, Partition, Goldbach's Conjecture, Euclid on Primes, Euclid's Fifth Postulate, Wilson's Theorem along with Lagrange's Proof of It and Pascal's Triangle, and Rational Human Intelligence," *Advances in Pure Mathematics* (www.scirp.org/journal/apm); doi of article: 10.4236/apm.2014.48051), Vol. 4, No. 8 (2014), pp. 400-466.

The following typos found in this article have been corrected in the present reprint of the article as Chapter 5 (references are to page and line of the original article): (425, 21) for "a common a goal" read "a common goal"; (444, 10) for "Iamblichus, who lived around 300 C.E., that" read "Iamblichus, who lived around 300 C.E., stated that"; (454, 17) for "the factorial of, 5" read "the factorial of 5"; (462, 3 up from bottom) move "[83]" to after "conventions" in the previous line; (463, 15) for "his three siblings had all died by age 2" read "his three siblings had all died by age 2, 3, or 5, or so"; (464, note 26, for "Dordrecht/Boston/London" read "Dordrecht/Boston/London, 1997").

A subsidiary aim of the present book is to provide some context to the five articles by adding a Retrospective and a Preface to their republication.

In the present Retrospective, a number of observations are presented revolving around the question: What is rational human intelligence? And also, perhaps more importantly in this early phase of the description of the complete theory, around the converse question: What is it not? One good test allowing one to distinguish rational human intelligence from other forms of human intelligence is as follows. Other forms of human intelligence tend to differ from one human being to another. Rational human intelligence is just about the same in all human beings who are capable of rational thought, which is most of humankind. And so it should if it is truly physical and mathematical.

In the Preface that follows the present Retrospective, an attempt is made to show how all of rational human intelligence can be derived from a single principle, in a way somewhat analogous to how J.-L. Lagrange derived all of the physics of matter and motion (as J. C. Maxwell calls it in his celebrated book entitled *Matter and Motion*), or also of mass and motion, or also of mechanics, from a single principle in his *Mécanique analytique*.

It is then indicated how this single principle is exploited in the five flavors in which rational human intelligence comes, as far as I can see at this time. In addition, there are combinations of the five flavors. The five flavors are as follows:

1) Contrast Digitality (ConDi);
2) Selection Digitality (SelDi);
3) Nexus Digitality (NexDi);
4) Certification Digitality (CerDi); and
5) Supplement Digitality (SupDi).

In earlier papers, I have anticipated the existence of only four flavors. They are 2), 3), 4), and 5). But as this project proceeded, it appeared necessary to add 1) as a distinct type of digitality. It is described in outline further below.

G. Boole described 1), 2), and 3) for the most part. J. Venn did much to clarify what 1), 2), and 3) are all about. I believe that I was able to add 4) and 5). The digital analysis of 4) and 5), phenomena that are either not treated or treated in entirely different ways in linguistics, did much to further the notion that rational human intelligence is entirely digital.

One striking feature that differentiates my approach from G. Boole's is that I treat the theory of rational human intelligence as a pure theory of physics and also call it that. It is a theory of physics with its own mathematics. And the mathematics in question was established for the first time in great part by G. Boole.

G. Boole did otherwise consider his theory mathematical. But it is important to realize that it is in the first place a theory of physics. The theory applies to a certain facet of the operation of the brain as a physical tool.

Rational human intelligence has everything to do with human beings and their brains. But it is important to keep the human element out of the theory of rational

human intelligence because the theory is physical and mathematical. Likewise, the laws of gravity may affect human beings. But the laws transcend the human dimension because they are physical and mathematical.

Nothing has been more inspiring throughout my investigations about rational human intelligence than the notion that the abilities of the brain are subject to absolute physical limitations. Nothing is more self-evident than that there are things that the brain can do and things that the brain cannot do. This automatically leads to the search for the line that separates what it can do from what it cannot do. And this in turn automatically leads to the belief that one should be able to describe all of it.

2. List of Earlier Efforts, Since about 1998

To make the record complete, I list below the other nine articles and books in which I have previously treated the topic of rational human intelligence, identifying between square brackets at the end which flavors of digitality are being discussed in them.

My understanding of the phenomenon of rational human intelligence has much evolved over the past fifteen years, ever since I first engaged it around 1998. The principal change came in late 2012, when inspired by J. C. Maxwell, I reached the conclusion that the theory of rational human intelligence is purely a theory of physics with its own mathematics—not a theory of linguistics, not a theory of neuroscience, not a theory of linguistics, not a theory of philosophy, not a theory of psychology, not a theory of theology, and so on. More on this below. The nine articles and books in question are as follows:

1) “Condition and Premise in Egyptian and Elsewhere and the Laws of Thought in Expanded Boolean Algebra,” *Zeitschrift für ägyptische Sprache und* Altertumskunde, Vol. 126 (1999), pp. 97-111. Reprinted in 2008, with slight modifications, in *The Other Mathematics* (see 5) below), pp. 261-283. [Nexus Digitality; Certification Digitality.]

2) “Contrast in Egyptian and in General and the Laws of Thought in Boolean Algebra,” *Göttinger Beiträge zur Sprachwissenschaft*, Vol. 2 (1999), pp. 37-60. Reprinted in 2008, with slight modifications, in *The Other Mathematics* (see 5) below), pp. 285-306. [Supplement Digitality.]

3) “The Meaning of the Coptic Particle RW,” *Journal of Coptic Studies*, Vol. 3 (2001), pp. 113-28, at pp. 127-128. [Supplement Digitality.]

4) “Questions and Related Phenomena in Coptic and in General: Final Definitions Based on Boole’s Laws of Thought,” in: J. E. Goehring and J. E. Timbie, Eds., *The World of Ancient Christianity*, The Catholic University of America Press, Washington, DC, 2007, pp. 72-94. [Supplement Digitality.]

5) “The Other Mathematics,” Gorgias Press, Piscataway, 2008, especially pp. 1-48, pp. 79-96, and pp. 261-321. [Nexus Digitality; Certification Digitality.]

6) “The Conjunctive in Egyptian and Coptic: Towards a Final Definition in Boolean Terms,” In: Ch. G. Häberl, Ed., *Proceedings of the* 35*th Annual Meeting of the North American Conference on Afroasiatic* Linguistics (NACAL 35), Cambridge Scholars Publishing, Newcastle Upon Tyne, 2009, pp. 12-30. [Nexus Digitality.]

7) “Towards the Full Digitalization of Grammar: The Case of the Egyptian and Coptic Nominal Sentence,” *Lingua Aegyptia*, Vol. 17 (2010), pp. 27-50. [Nexus Digitality; Supplement Digitality.]

8) “From ‘My Body’ to ‘Myself’ to ‘Me Too’: Philological and Digital Analysis of a Triple Shift in Egyptian,” *Journal of the American Research Center in Egypt*, Vol. 45 (2009) pp. 247-290. [Supplement Digitality.]

9) “Zur unausweichlichen Digitalisierung der Sprachbetrachtung: ‘Allein’, ‘anderer’, ‘auch’, ‘einziger’, ‘(seiner)seits’, und ‘selbst’ als digitales Wortfeld im Ägyptisch-Koptischen und im Allgemeinen,” In: A. I. Blöbaum, K. Butt, and I. Köhler, Eds., *Lexical Fields, Semantics and Lexicography*, Aegyptiaca Monasteriensia, Vol. 7, Shaker Verlag, 2011, pp. 5-38. [Supplement Digitality.]

3. George Boole and Rational Human Intelligence

As was noted above, the task that I plan and hope to undertake in the near future is to describe the physical and mathematical theory of rational human intelligence—all of it. Because I am convinced that it can be done.

In fact, G. Boole did much if not most of it, though not quite all of it. The nature of

the whole effort is therefore at the same time in large part to demonstrate how G. Boole made it much if not most of the way to a comprehensive theory of rational human intelligence. In that regard, the present effort to describe all of rational human intelligence is hardly something that comes totally out of the blue.

Meanwhile, I still have not been able to figure out how G. Boole did what he did. But he did. And much if not most of what needed to be done. J. Venn already mused that it can only rarely have happened in the history of science and mathematics that someone took on an old and venerable field, in this case what is known as logic, and completely solved it following more than 2000 years of intense engagement by many others, ever since Aristotle.

And yet, it seems now universally accepted that G. Boole tried to describe how we think rationally and failed. This is one serious challenge and obstacle that the present project faces. Furthermore, the claim that rational human intelligence can at the present time be described in its entirety may encounter much incredulity. That is another serious challenge and obstacle that the present effort faces. It is difficult to counter these challenges head on until the finished product is ready for inspection. Then the proof ought to be in the pudding, as it were.

4. Rational Human Intelligence as a Theory of Physics, Like the Theory of the Physics of Matter and Motion, but with a Different Mathematics

The claim that rational human intelligence can be formulated in its entirety may baffle many, if not all, considering that the human brain remains a bit of a mystery, to say the least. The careful description of the 100 trillion connections between neurons—or however many there are—is still quite some time away and provisional efforts towards such a description have only recently begun.

However, there is no need to know all those connections in order to formulate the theory of rational human intelligence. The theory is mathematical and physical.

An analogy may be useful to clarify how it is so.

In the physics of matter and motion, the laws of gravity are physical and mathe-

matical. In other words, it does not matter whether the laws find expression in an apple falling from a tree or the moon circling the earth. The apple and the moon are only physical mediums in which the mathematical and physical laws of gravity are manifested. But the laws exist independently from the apple and the moon.

In the same way, the laws of rational human intelligence are physical and mathematical. They exist independently from how they are expressed in the physical medium of the human brain. Still, it does remain as profoundly interesting as it was before to discover how these laws manifest themselves on the biochemical platform of the human brain, with the propagation of electricity playing a key role. But that will be a task for biochemists, bioengineers, computer scientists, and neuroscientists, less so for physicists and mathematicians.

There is no mention of apples or the moon in manuals of physics, except perhaps in the examples. There therefore *does not need to be any mention of the human brain as a biochemical object in a description of rational human intelligence*.

Nor will there be a need for supercomputers to describe rational human intelligence, as some might perhaps assume. I. Newton—who hailed from Lincoln, England, just like G. Boole—did not even use a calculator to formulate the laws of gravity, let alone a supercomputer. Did A. Einstein use calculators to refine I. Newton's theories?

Then again, supercomputers will be needed, it looks like, to track the activity of every single neuron in the brain. The amount of information is just colossal.

In other words, the order of research will be to first formulate the physical and mathematical theory of rational human intelligence and then to go look for it in the brain.

5. Neurons and Rational Human Intelligence

The brain is all about neurons. But rational human intelligence does not happen on the small scale level of the neurons as has often been assumed, even if neurons are evidently active in the process of producing rational human intelligence. Nor do neurons function in the same way as transistors do in a computer, even if both function digitally. I hope to describe the difference in function between the two types of digitality in detail elsewhere.

Why then does the brain consist of all these tiny neurons instead of some other conceivable biochemical structure? Provisionally, I can see neurons performing two important functions.

The first is to help in the propagation of electricity. In this respect, neurons are a little bit like relays in a telegraph. Electricity sent through a wire peters out rather fast. Coating the wire helps. In the same way, the neuron's axon is coated. But coating only helps that much. In that regard, a succession of interconnected neurons makes it possible to propel electricity over longer distances—each neuron kicking the can further down the road, as it were.

The second function of neurons is to make maximum complexity and flexibility possible in a rather physically limited biological mass, the human brain. Only so much biological mass can go under the human skull. It is not quite the division of this mass into tiny neurons that allows great complexity. It is the connections between the neurons. Theoretically speaking, x neurons can be connected in $(x - 1)!$ ways. For example, four (4) neurons can be connected in 3! or, 3.2.1 = 6 ways starting from any of the four. A simple drawing clarifies the matter. Factorial (!) is a function that rapidly increases. Thus, just 10 neurons can be connected in 362,880 or between three and four hundred thousand ways. With ever more neurons, the connections increase gigantically. Evidently, not every neuron is connected to every other neuron in the brain. Still, the number of connections should be colossally large by any count. I quote the number 100 trillion from the popular scientific literature. The exact number is irrelevant to the present argument.

6. What Is Rational Human Intelligence?

Someone asked me whether a complete theory of rational human intelligence could be used to know what other people are thinking. It definitely could not. Clearly, the theory is not about *what* people are thinking but about *how* they are thinking. It is like describing *how* a car engine functions independently of *what* the engine ends up doing and *where* it ends up taking the car. Rational human intelligence is also more or less the same in all rationally thinking human beings. By contrast, there is no way in which any two human beings could have all the same thoughts.

There is evidently much more to the thinking brain than rational human intelligence. In other words, there is so much in terms of brain activity and thought that is

not rational human intelligence. How is it possible to separate out rational human intelligence from all that the brain does? To understand what rational human intelligence really is, it is very helpful to determine what all it is not. In the next section, some concepts that are part of the world of thought without being rational human intelligence will be discussed and it will be indicated what sets these concepts apart from rational human intelligence.

As to what rational human intelligence *is*, the simple if not simplistic answer is that it is the complete physical and mathematical theory to which it is subject.

Likewise, one might ask: What is the complete theory of electromagnetism? It is for the most part J. C. Maxwell's physical and mathematical theory of the phenomenon, which is epitomized in four celebrated Equations, exactly that and not that much more.

7. Rational Human Intelligence, What Is It Not? Four Differences with Other Types of Human Intelligence

7.0. The claim that all of rational human intelligence can be described in its entirety may elicit much—if not all around—skepticism. And in equal measure might the afore-mentioned claim that rational human intelligence has in fact already been described for the greater part more than 150 years ago by G. Boole.

A principal source of the skepticism is likely to be the following. Human intelligence seems to be so diverse. The impression may arise that a theory of rational human intelligence will explain everything about how human beings think. This impression would be mistaken. There is much more to human thought than rational human intelligence. One might speak of artistic intelligence, emotional intelligence, literary intelligence, musical intelligence, religious intelligence, political intelligence, social intelligence, and this list could go on for a long stretch.

What is the difference between these many other types of human intelligence and rational human intelligence? This is evidently not the place to analyze other types of human intelligence. The domain is vast. The narrow focus of the larger project of which the present book is part is rational human intelligence. The following suggestions are therefore very provisional as far as other forms of human intelligence are concerned.

7.1. Difference One: Rational Human Intelligence Is Entirely Digital-Mathematical

A first difference between rational human intelligence and other types of human intelligence is that none of the many other types of human intelligence are entirely digital in the way that rational human intelligence is. Then again, other types of human intelligence may employ rational human intelligence as a kind of vehicle. Rational human intelligence is part of them, so to speak. This is true for all the forms of human intelligence that involve language.

The focus is on language. There is no rational human intelligence without language. Conversely, all reasonable language exhibits rational human intelligence. It follows that any other form of intelligence that involves the use of reasonable language also exhibits rational human intelligence as a part of it. More on this in the next section.

7.2. Difference Two: Chemicals Play No Essential Role in the Structure of Rational Human Intelligence

As a physical event, rational human intelligence is evidently of a biochemical nature. It is after all an activity of the brain. And all that happens in the brain is biochemical in nature and revolves entirely around the propagation of electricity as propelled by neurons.

However, this chemistry is not part of the structure or essence of rational human intelligence in the way that it is of emotional intelligence. This could already have been derived from the observation made above that the structure of rational human intelligence can be entirely described in mathematical terms independently of the structure of the brain, just as the physics of motion can be entirely described in mathematical terms independently of an apple falling from a tree. By contrast, the release of, say, dopamine in the brain is itself very much part of emotional intelligence.

In other words, the second difference between rational human intelligence and many other types of human intelligence is that the “juices” play a role in many, if not all, other types of human intelligence. The “juices” include substances such as adrenalin, dopamine, and serotonin. The release of them is not digital, 1 or 0, On or Off. It is analog, as it were. One can always be a little less or more happy and a little less or

more angry.

7.3. Difference Three: Rational Human Intelligence Is the Same in All Reasonable Human Beings

The physical and mathematical theory of rational human intelligence cannot be physical and mathematical if it manifests itself differently in different human beings. Mathematics is supposed to be completely independent of such individual variety. If it were, how could it still be mathematics? Accordingly, rational human intelligence simply must be the same in all reasonably thinking human beings.

All this means that one cannot just decide to change rational human intelligence. It is a mathematical structure. One is subject to it just as much as one is subject to 1 + 1 = 2. If one did change it, one would no longer be understood or no longer function.

There is a difference between the mathematics of 1 + 1 = 2 and that of rational human intelligence. 1 + 1 = 2 applies to all of physical nature. Rational human intelligence applies only to rational thought. Therefore, rational human intelligence could conceivably change or evolve. But as it did, it would need to remain the same in all reasonable human beings if these human beings are to understand one another.

This consideration of the sameness of rational human intelligence provides an easy test to differentiate between rational human intelligence and most, if not all, other forms of human intelligence. I will limit myself to one example: knowledge. A comparison between rational human intelligence and knowledge may be useful. Both seem to have everything to do with human intelligence. Is knowledge not all about who we are as intelligent human beings? Then how could it possibly be something different from another capacity of the brain such as rational human intelligence?

One thing is more than obvious. Knowledge is different from person to person. In fact, it differs over time in a single person. No such difference characterizes rational human intelligence. It is otherwise clear that rational human intelligence initially has to start growing in the brains of newborns. But when it has reached its full mathematical structure, it remains basically the same for a lifetime. Healthy rationally thinking human beings as a rule remain rational human beings more or less in the same way throughout their lifetime.

The study of how we know things is called epistemology, which includes the Greek word *epistēmē* "knowledge." By contrast, the term "rational human intelligence" includes Latin *ratio*, as in *ratiocinari* "to reason".

7.4. Difference Four: Rational Human Intelligence Has No Historical Dimension, Though Not Necessarily in Deep Time

Rational human intelligence does not change over time. Thus, one can still read works from the sixteenth century and recognize one's own intelligence in what is written. Rational human intelligence is an unchangeable mathematical structure.

Rational human intelligence evidently has to be built up from birth. But, once in place, it more or less stays the same for a lifetime. What is more, it also has had to be built up on a much larger timescale, from the dawn of mankind. It is clear that the Neanderthalers were not as intelligent as we are. Some kind of an evolution must therefore have taken place in regard to rational human intelligence over the millennia. This evolution must have had everything to do with language. There is no rational human intelligence without language, though there may be emotional intelligence and other kinds of intelligence without language. It may be surmised that the rise of rational human intelligence went more or less hand in hand with the rise of language.

Can an increase in the sophistication of rational human intelligence be noticed in the historical period, that is, the period of human history from which we have writing, now about 5000 years long? I have elsewhere discussed the possibility, namely in my *The Other Mathematics*, already cited above [1]. But the proposed increase is rather minor, though not insignificant.

The historical dimension of other types of intelligence may be illustrated by an example. Consider the metaphor. Metaphors are part of literature. But they are by no means confined to literature. Much has been written about metaphors and many attempts have been made to define it.

One example of a metaphor is the rose as a metaphor for love. Clearly, the rose is not a metaphor for love with all peoples in the world. Some people live in areas where there are no roses.

In general, very often, one person's metaphor will not be another person's metaphor. The metaphor cannot therefore be part of rational human intelligence, which ought to be the same for everyone.

Another example of a metaphor is the shoes that one decides to wear as a metaphor of what one wants to project as one's personality. Why is it that a person A chooses to wear a pair of shoes B? The matter is not easy to answer. Yet, one likes to think that everything happens for a reason. And one has every right to think that way. What needs to be considered is all the factors that made person A who he or she is and all the factors that led up to the decision of person A to wear pair of shoes B. What also needs to be considered is all the factors that led up to the manufacturing of a specific array of choices in shoes that were available to person A as the result of a long history of shoemaking. Surely, it would be possible to say a lot about all that. But everyone would probably agree that completeness is impossible to achieve. Too many factors are in play, including all of person A's forebears, who in the end made A into what he or she is.

It is possible to say a whole lot about metaphors, in literature and elsewhere. And many people have. But it is impossible to capture all of what makes a metaphor a metaphor owing to the historical dimension. In history, as distinct from mathematics, final answers are not possible. Historians ask questions such as: What caused World War II? Everyone agrees that there is much that is sensible that can be said about the matter that hits close to home. But is there anyone out there who thinks that it is possible to give a final mathematical answer to this question? I am quite sure that there is not.

By sharp contrast, rational human intelligence must be a closed and finite system because it is physical and mathematical.

8. Rational Human Intelligence Relates to Other Types of Human Intelligence Involving Language as the Physics of Motion Does to the Other Sciences

It was noted in the preceding section that rational human intelligence is typically a core component of other forms of human intelligence involving language. Similarly, all agree that sciences such as chemistry and biology presuppose the laws of physics.

In that regard, physics is a kind of foundation or a kind of essential core in the realm of the sciences. One might even say that, in some sense, physics is everything.

In the same way, the physics of rational human intelligence is implied in all the forms of human intelligence that involve language. There is no rational human intelligence without language and comprehensible language always exhibits rational human intelligence in addition to what else it may exhibit.

Consequently, there is something opportune about beginning the comprehensive description of human intelligence—an effort that will take decades, if not centuries—with the description of rational human intelligence. What is more, I believe that rational human intelligence can at this point already be described in its entirety. So one might as well go ahead, so to speak.

Circumstances make it necessary to approach the study of rational human intelligence with matters being turned on their head. How so?

9. Turning Matters on Their Head: From Language Back to the Brain rather than the Other Way Around

Evidently, what happens is that the brain generates rational human intelligence and externalizes it in the form of language. Accordingly, one would think that the natural starting point of the description of rational human intelligence would be the brain. But as was just said, such a thing is impossible at this time. The reason is that the structure of intelligence inside the brain is almost entirely opaque. Consequently, matters need to be turned on their head in that it is necessary to begin with what rational human intelligence produces externally outside the brain, namely reasonable language, and try to reconstruct which structure inside the brain generated that product.

For such a thing to be possible, what comes out of people's mouths ought to reflect exactly what is inside their heads. What guarantee is there that this is the case? The guarantee is that people feel reasonably confident that what their mouth projects corresponds to what is inside their brains, that is, corresponds to their inside voices. One can in fact "speak" inside one's brain without uttering a sound. The alternative is that we would often be saying something that differs from what we think that we are saying. If this were possible, chaos would soon ensue.

In sum, there is every reason to believe that a physical and mathematical analysis of what comes out of people's mouths can yield a theory of what happens inside the brain. The platform inside the brain is different. It is biochemical. But the biochemical processes operate according to physical and mathematical principles established on the basis of observations of what comes outside the mouth.

The title of the present book includes three adjectives referring to three paragons of mathematics and science: G. Boole, J. C. Maxwell, and J.-L. Lagrange. The appearance of G. Boole is hardly a surprise. But why J. C. Maxwell and J.-L Lagrange?

10. What Is Lagrangian and Maxwellian in the Physical and Mathematical Theory of Rational Human Intelligence?

10.1. But First Something on "Boolean"

The physical and mathematical theory of rational human intelligence owes much if not most everything to G. Boole. And this is hardly the first time that I acknowledge J. Venn for shedding much welcome light on G. Boole's ideas.

The mathematician E. Schröder also deserves special mention for comprehending G. Boole more deeply than most everyone. But E. Schröder treated G. Boole's theory too much as pure mathematics. It is not. It is a theory of physics with its own mathematics. It is clear that G. Boole thinks of his own theory as mathematics. But his countless references to thought and language can be understood as references to thought and language as physical events. In G. Boole's time, physics and mathematics were not yet as clearly distinguished as they are now. G. Boole himself did therefore not have much incentive to interpret his theory explicitly as a theory of physics. But so much in his theory is physical rather than mathematical.

Now that the distinction between mathematics and physics is much sharper, there is no longer any obstacle to classifying G. Boole's theory unequivocally as a theory of physics with its own mathematics. The theory does after all concern a physical phenomenon, the propagation of rational intelligence in the human brain. This event is 100% physical in every which way. Something is happening in the material world when rational human intelligence takes place. And it can be fully accounted for by a

theory of physics.

In the recent past, I have taken to styling the theory of rational human intelligence—which I intend to describe 100% in full—as a mathematical and physical theory. But the more I think of it, styling the theory as physical and mathematical rather than as mathematical and physical more suitably evokes what I believe to be the undeniable fact that the theory is first and foremost a theory of physics with its own mathematics.

The appearance of the term “Boolean” in the title of this book requires little if no justification. But what about the terms “Lagrangian” and “Maxwellian”?

10.2. J.-L. Lagrange and J. C. Maxwell

The decision to add “Maxwellian” and “Lagrangian” to the title of this book is owed to critical influences from J. C. Maxwell and J.-L. Lagrange in the shaping of the theory.

This influence came in two stages. The first stage is dated to late 2012 and pertains to J. C. Maxwell and hence by extension to J.-L. Lagrange. The second stage came in mid 2014—I noted June 11 somewhere—and pertains to J.-L. Lagrange.

J.-L. Lagrange was a mathematician, perhaps the keenest one of the eighteenth century. G. Sarton has described the personality of this most remarkable intellect [2].

J. C. Maxwell was the first to show that light is part of the same phenomenon as electricity and magnetism. He also computed the speed of light in a theoretical manner. His discovery placed light and the speed of light at the very center of physics. But it also raised new problems pertaining to the relation between electromagnetism and Newtonian physics. This is where A. Einstein picked up. The speed of light became the yardstick of everything, as it were. I read somewhere that A. Einstein kept two photographs in his office, one of J. C. Maxwell and the other of M. Faraday.

But it is for another facet of his work that I deem J. C. Maxwell’s work to be relevant to the theory of rational human intelligence. To J. C. Maxwell belongs the merit of being the only physicist to have described just about in full one of the four main forces of physics whose existence is universally recognized in physics. No one else

has accomplished a similar feat. The force in question is the electromagnetic force. The theories of the other three forces remain incomplete. These three forces are as follows: 1) the weak force; 2) the strong force; and 3) the gravitational force.

The physicist R. Feynman famously opined that, thousands of years from now, "Maxwell's discovery of the laws of electrodynamics" will come to be considered as "the most significant event of the 19th century". R. Feynman was a physicist who built on J. C. Maxwell's theories. So he was possibly a little biased. But still.

The connection between gravity and electromagnetism remains poorly understood. Then again, there has to be some relation. C. A. de Coulomb (1736-1806) established that the force between charges (strictly speaking: point charges) or two charged particles is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. Along the same lines, I. Newton had earlier established that the gravitational attraction between two objects in space is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. The fundamental similarity between the two facts is striking. But no one has any (certain) idea as to what it exactly means.

10.3. "Maxwellian"

The first influence came with the realization that J. C. Maxwell's theory of electromagnetism is not only a black box theory but also a complete theory.

A black box theory is a theory that says, or knows, nothing about the physical constitution of the material of which it describes the physical properties. The nature of a black box theory is described in more detail in the article that is reprinted as Chapter 4 of the present book. One has to derive what is in the box from what comes out of the box without being able to look inside the box. The box is black, in the sense of opaque, because one cannot look inside it. After all, J. C. Maxwell did not even know what an electron is. He relied in large part on the researches of M. Faraday as to what electricity and magnetism do without asking what they are.

What is more, not only is J. C. Maxwell's theory a black box theory. It is also more or less complete.

Not only had it not occurred to me that a black box theory could be so far-reaching.

It also had never occurred to me that such a theory could in fact be complete.

It soon appeared to me all at once, in light of J. C. Maxwell's theory, that the theory of rational human intelligence exhibits three eminent and undeniable properties, the following.

Property 1 (*physics*): *It is a theory of physics with its own mathematics.*

Property 2 (*black box*): *It is* (*for the time being*) *a black box theory. But that does not detract in the least from its validity and reach. And it will not change when it is no longer a black box theory in the future.*

Property 3 (*completeness*): *It can be described in its entirety. It can be made complete.*

Up to that critical juncture in late 2012, I had no idea that a theory exhibiting any of these three properties could be postulated. Instead of the three properties, there was much doubt: with regard to property 1, doubt as to what exactly I was doing; with regard to property 2, doubt about whether what I was trying to do was at all possible; with regard to property 3, doubt about how much of it could be done.

But at that very critical juncture, it became clear to me personally all at once

1) what I was doing,
2) that what I was doing was possible, and
3) that I could do all that needed to be done.

As regards property 1, I had been much engaged with all of G. Boole's writings on thought and probability since 1998. His writings presented what appeared to me to be fully satisfying and final solutions to certain linguistic problems. The articles in which these solutions are proposed have been listed above.

But it remained less than 100% clear to me what exactly I was doing. It seemed obvious that mathematics was part of it. G. Boole repeatedly stresses the mathematical character of his theory. But was there more than just mathematics? Was there also linguistics involved? Neuroscience? Philosophy? And so on.

In this regard, my understanding of the nature—though not of much of the actual contents—of J. C. Maxwell's theory of electromagnetism made it all at once apparent

to me personally that the theory of rational human intelligence is a theory of physics with its own mathematics. And that is all there is to it. There is no need to look any further, even if there evidently are other types of human intelligence.

As regards property 2, there was apprehension on my part as to whether trying to describe rational thought and language was justifiable since the workings of the physical brain remain to this day mostly opaque. Should one not rather remain silent and wait until the brain is known better?

In this regard, my understanding of the nature—though not of much of the actual contents—of J. C. Maxwell's theory of electromagnetism made it all at once apparent to me personally that there is no need to know anything about the actual biochemical workings of the brain to construct a theory of rational human intelligence.

As regards property 3, it had appeared to me that everyone would probably agree that, in terms of rational human intelligence, there are certain things that the brain can do and certain things that it cannot do. How could the powers of the brain be limitless? It follows that there must be a dividing line somewhere between what the brain can do and what it cannot do. It would therefore be of great interest to find that line. How smart are we really? But finding the line implies knowing the extent of rational human intelligence. One can only determine precisely what the brain cannot do if one knows all that it *can* do.

In this regard, my understanding of the nature—though not of much of the actual contents—of J. C. Maxwell's theory of electromagnetism made it all at once apparent to me personally that rational human intelligence can be described in its entirety.

I write at greater length about the comparison between the theory of electromagnetism and the theory of rational human intelligence in Chapter 4.

10.4. The Long and Winding Road to J. C. Maxwell

10.4.1. Connecting G. Boole's *Laws of Thought* with Modern Mathematics and Science

G. Boole wrote his *Laws of Thought* in a very flowery Latinate Victorian English and he published it a long time ago in 1854 [3]. It all makes his book look very distant,

and even divorced, from contemporary hard science in terms of style. As a result, one may also easily gain the impression that it is distant from modern science not only in style but also in substance. Then again, the book is essentially about mathematics. There is supposed to be something timeless about mathematics. In that regard, L. Euler's works of the eighteenth century are still the latest hottest on the subject.

It is also the case that the book is not widely read (if it ever was). And, when so, then probably mostly only for its place in the history of higher learning. I have never seen the book listed as required reading in any class in any field of the sciences (or also of the humanities, for that matter). Still, there has been a modest revival of interest in G. Boole's work in the last couple of decades.

In any event, it seemed desirable to seek a foothold of my engagement with G. Boole's work somewhere in the hard sciences—in an attempt to modernize his work, as it were, or perhaps just to add a modern veneer. And I undertook such a search in 2011 and much of 2012.

But what I ended up finding was something completely different from what I was seeking: a means of fashioning and completing G. Boole's ideas into an exhaustive physical and mathematical theory of rational human intelligence. And not with the help of something more recent and new. But rather with the help of someone who was a younger contemporary of G. Boole, J. C. Maxwell. But it took a long detour to get there. This detour is described in what follows.

In casting about for even just a toehold in recent trends in hard science, I acquired all kinds of introductions to fields of learning that might potentially be relevant. But I stopped at psychopharmacology. What I would find in an introduction to psychopharmacology might perhaps be relevant to emotional human intelligence. But I could not see how it could be relevant to rational human intelligence.

All the books that I acquired received high acclaim and there is no doubt that they excel in communicating useful information on their respective subjects. But most of them did not give me what was needed, it soon appeared. I therefore read none of them completely. I only read them as far as was necessary to establish that they appeared to me to be dead ends in as far as the description of rational human intelligence is concerned. There is absolutely no time to become an expert in all kind of fields all at the same time. Conservation of energy was mandatory. The available time is not endless.

I cannot establish the precise order in which I perused the books cited below. But the order in which they are presented should accord very roughly with the order in which I accessed them. I do not see the need for complete bibliographical references in this retrospective. All the books should be easy to find based on the data provided. It is also more evocative of the points that I am making that the titles of the books appear in the main text.

10.4.2. First Stop: Computer Programming

My attention early on turned to the concept of the digital and therefore to computer science. Surely, something that is relevant to rational human intelligence ought to be found in computer science. I had myself used the term "digital" in several publications. They are cited above. And what is more digital than computers?

So I bought a couple of books on programming, in my case J. L. Ford, Jr.'s *Programming for the Absolute Beginner* (2007) and Ch. Petzold's *Programming in the Key of C#* (2004), published by Microsoft Press. There are so many. As I was making my way through the early chapters, it very soon became clear that programming tells one little or nothing about the architecture of the computer itself. The fact is rather evident. But not to someone who has never come anywhere close to programming. J. L. Ford, Jr. expresses this notion quite clearly, as follows (p. [xiv]):

You do not have to be a computer genius to learn how to program. While most people have only a very limited understanding of the internal mechanics of a car or motorcycle, they do not let that stop them from getting behind the wheel and learning to drive. Nor do you have to know how to build a computer from scratch or possess detailed understanding of the inner workings of your computer's motherboard, hard drive, or any other hardware component in order to be able to operate a computer. The same is true of computer programming.

10.4.3. Second Stop: Computer Architecture

10.4.3.1. Digital Design

Programming was clearly not what I needed. I did not need to learn how to drive. What I needed instead was to know how the mechanics of the car or the motorcycle

works. In that regard, Ch. Petzold's *Code: The Hidden Language of Computer Hardware and Software* (2000), likewise published by Microsoft Press, was very helpful. It is designed for absolute beginners and does what it purports to do very successfully. I return to Ch. Petzold's *Code* below.

Meanwhile, I did also acquire one book that beginning pros would use to learn how to build a computer, namely J. D. Daniels's *Digital Design from Zero to One* (1996). I often peeked in it for overall inspiration. I also read parts of J. R. Gregg's *Ones and Zeros: Understanding Boolean Algebra, Digital Circuits, and the Logic of Sets* (1986). The mention of G. Boole is what first drew my attention to this latter book.

10.4.3.2. Notes on the History of Computer Science, Including on A. Turing and K. Gödel

Since computers scream "digital", and I am a bit of a historian in my other work, I felt a need to know more about the history of the computer. I already knew about the pivotal efforts by C. E. Shannon in the late 1930s, at the outset of the modern computer age, and about the connection of C. E. Shannon's efforts to G. Boole's work. I have written elsewhere about how I find these efforts significant.

In addition, I acquired—and read many extracts of—two well-regarded books pertaining to the history of the computer: H. H. Goldstine's *The Computer from Pascal to von Neumann* (1980, republished in 1993 with a new preface) and A. R. Burks's *Who Invented the Computer*: *The Legal Battle That Changed Computing History* (2003).

The name A. Turing evidently occupies a central place in the history of computer science. He is kind of a rock star in the field. And his decipherment of the Enigma code was quite clever, to say the least. For my general personal enlightenment, I now own copies of the following three books.

The first is the anthology of A. Turing's essential writings edited by B. J. Copeland, *The Essential Turing*: *The Ideas That Gave Birth to the Computer Age* (2004). I could not find G. Boole's name in the index of this book.

The second is Ch. Petzold's *The Annotated Turing: A Guided Tour through Alan Turing's Historic Paper on Computability and the Turing Machine* (2008). Ch. Petzold is gentle and respectful in his analysis of A. Turing's well-known article "On

Computable Numbers, with an Application to the Entscheidungsproblem" (1936). But I refrain from listing all the many quaint ways in which he describes himself as not being a little perplexed by A. Turing's line of argument. A. Turing's effort was clearly heartfelt. But, in the end, it seems very confused to me.

A. Turing's article has everything to do with K. Gödel's much revered Incompleteness Theorem. I personally harbor many mixed thoughts about this theorem. And I have not been entirely alone. I am equally doubtful about the entire logics movement from G. Cantor to B. Russell, which was designed to find the roots of mathematics and has been so well described in I. Grattan-Guiness's *The Search for Mathematical Roots*, 1870-1940 (2000). The efforts documented in this book are sincere. But the book reads like a record of failure on the part of the movement. One prominent figure in said movement is the much worshiped G. Frege. There seem to be two G. Freges: 1) the Antiboole, whom better acquaintance with G. Boole's work might have benefited; 2) the Unfrege, a philosopher of all of language and mathematics who never existed but many think did. When it comes to G. Boole and G. Frege, I personally strongly believe that there was a winner and a loser. And G. Frege lost.

K. Gödel's theorem has everything to do with indeterminate algebra. It was K. Gödel's engagement with indeterminate algebra that led to A. Turing's article. Indeterminate algebra concerns problems like the following: In how many ways can 10 people be composed of men and women? There are 11 different answers: there can be 0 women and 10 men, 1 woman and 9 men, 2 women and 8 men, and so on. In other words, there is no single determinate answer. However, the number of answers is mathematically fixed. In this connection, I quickly reacquainted myself in broad lines with the little that I know about the ancient Greek mathematician Diophantus and indeterminate algebra. Most of this knowledge is derived from L. Euler's *Elements of Algebra* and the additions to it by J.-L. Lagrange. The mission was at all times to seek a foothold for G. Boole's theory in modern science and mathematics.

10.4.3.3. The Digitality of the Computer and the Digitality of Rational Human Intelligence

My main guide in understanding the basics of computer architecture was Ch. Petzold's *Code*. But as I reached the middle of the book, after having learned more about logic gates (gates were already familiar to me from Boolean algebra), half-adders, adders, flipflops, and so on, it became increasingly clear that computer intelligence is not in any way like rational human intelligence, even if both are digital. I hope to

describe the difference between the two modes of digitality elsewhere in detail. As a consequence, I abandoned my efforts to find a foothold for G. Boole's theory in computer science, even if it was G. Boole's ideas that ultimately spawned the digital age. Still, I intend to describe at some point in exact terms how the digitality of rational human intelligence and the digitality of the computer relate to one another.

Where to turn to next? So far, I had looked for inspiration in machines. Computer science—and all that comes with it, Internet, social media, and so on—has been so successful in recent decades that it seemed like a most evident first place to go to. But I could not find what I was looking for. On to something else.

10.4.4. Third Stop: Neurons and Neural Networks

If the machines did not deliver what was sought, then what about the human beings? There is no doubt that rational human intelligence is produced by the human brain. What about the human brain? It is evidently made up of neurons, billions of them.

It is also well-known that Broca's area and Wernicke's area on the left side of the brain have much to do with language and therefore presumably also with rational human intelligence. I read what I could about them.

I acquainted myself with how neurons propel electricity. I learned about Action Potential and the role of sodium, calcium, and potassium in the process. Animations of how a neuron works are easy to find on the Internet. They show how electricity is propelled through a neuron's axon, a kind of stem emanating from the nucleus of the neuron, and how that axon connects with one of the dendrites, a kind of tentacles, of another neuron so that the electric current is propelled onward through the second neuron's nucleus and its axon to a dendrite of yet a third neuron. And so on.

It is evident that the neurons operate in a network. They are interconnected. There is in fact a whole field devoted to how neural networks might shed light on human intelligence. It is common in this field—though apparently less common in more recent times—to think of the neuron as an equivalent of a transistor in a computer, which is the equivalent of an electric switch in earlier computers; I read about transistors, just in case. A neuron fires or it does not fire. A transistor (earlier, a switch) transmits electricity or it does not transmit electricity. Both exhibit On-or-Off, or one (1)/zero (0), behavior.

A well-known early effort to locate rational human intelligence on the level of the tiny neurons is J. von Neumann's Yale Silliman lectures of 1956, published as *The Computer and the Brain* (1958), which I perused. Early protagonists in the field of neural networks and the like were N. Wiener, W. S. McCulloch, and W. Pitts. I had a look at two of the very earliest efforts along these lines, namely the following: 1) W. S. McCulloch's and W. Pitts's "A Logical Calculus of the Ideas Immanent in Nervous Activity" in the *Bulletin of Mathematical Biophysics* of 1943 [4]; 2) the same authors' along with H. D. Landahl's "A Statistical Consequence of the Logical Calculus of Nervous Nets", in the same volume [5]. Remarkably, G. Boole and the functions AND, OR, and NOT are mentioned in the latter article in his notation, namely +, ×, and 1−, just five years or so after C. E. Shannon first introduced G. Boole's algebra into electrical engineering.

I learned much about neural networks as a field of learning from two works that appear to be classics. One is J. A. Anderson's *An Introduction to Neural Networks* (1995). The other is *Talking Nets*: *An Oral History of Neural Networks* (1998), edited by J. A. Anderson and E. Rosenfeld. Closely related fields are artificial intelligence and cybernetics, in which M. Minsky has been a prominent voice.

Thus I learned that sophisticated networks are being constructed in theory and in hardware. These networks appear to be fully valid within their own framework. But it soon became obvious to me that such networks have nothing to do with rational human intelligence. Perhaps, they will someday be useful for mapping other capabilities of the brain, for example vision. And perhaps, they will even be useful to map the biochemical platform that rational human intelligence inhabits inside the brain.

But I could not find any direct connection with the structure of rational human intelligence by way of extending a bridge to G. Boole's theories. Rational human intelligence does not take place on the small scale of the neuron. It takes place as clusters of neurons interact.

I had apparently reached another dead end. But what else is there to seek a connection with?

10.4.5. Some Other Dead Ends

While engaging computer programming, computer architecture, and neural networks,

I cast about for anything else that might possibly be relevant in the realm of mathematics and the sciences.

On the lookout for any other fields that might possibly be relevant to the cause of rational human intelligence, I asked myself: Is there anything relevant to be found in 1) probability, 2) calculus, 3) the so-called mathematical theory of communication, and 4) brain science? I perused certain select books and roamed the Internet in an attempt to make a determination in this regard.

1) I looked intently at the theory of probability, because G. Boole was the first to demonstrate that probability is part quantitative mathematics and part digital mathematics. More on this matter is found in Chapter 1 and Chapter 2. G. Boole's ideas on probability have been almost entirely bypassed by the field.

G. Boole died in 1864. That year seems to mark some kind of a transition in the history of probability. Probability started looking quite differently from then onward. The non-mathematician may be surprised to learn that there is, alongside objective probability, also a type of widely practiced subjective probability whose very subjectivity seems rather uncharacteristic of what one thinks of as mathematics. One would like to think that there is supposed to be no fudge factor in mathematics. Not so with all of probability and statistics these days.

It was in 1865 that the encyclopedic history of the theory of probability by G. Boole's acquaintance I. Todhunter appeared, his *A History of the Mathematical Theory of Probability from the Time of Pascal to That of Laplace*. There has not been something like it ever since. And it was in 1864 that the fourth edition of S.-F. Lacroix's *Traité élémentaire du calcul des probabilities* was published. I learned much from these two books. I. Todhunter's and S.-F. Lacroix's books are looking backward in a way to serve as a kind of final exclamation points to a period in the history of probability that was coming to an end. Perhaps, I will have the opportunity to expand on this milestone elsewhere.

As regards probability, I was able to confirm for myself—as G. Boole first established—that there is definitely a deep connection between rational human intelligence and probability. I intend to elaborate on this deep connection in detail elsewhere. But that does not mean that probability sheds a direct light on rational human intelligence. In that respect, at least, it is a dead end.

2) I looked again at the basic insights of calculus. I discuss the relation between rational human intelligence and calculus further below. Calculus seems like such a splendid achievement of mathematics. Could it do anything for the cause of rational human intelligence? After careful consideration, it appears that it plays no role in the physical and mathematical theory of rational human intelligence. The reason is that calculus belongs to quantitative mathematics, which studies that which is capable of increase and diminution. Things get bigger and smaller. Things do not get bigger or smaller in the digital mathematics of rational human intelligence.

3) And I looked for the first time at what is called the mathematical theory of communication, perusing C. E. Shannon's and W. Wever's much cited *The Mathematical Theory of Communication* (1949). After thumbing back and forth in this work, I am still not 100% sure as to what this is exactly all about. In any event, it is not about rational human intelligence.

It seemed as if I was beginning to run out of options. I could find no way of connecting G. Boole's theory more firmly with the most modern mathematics and sciences. What was this theory presented by this great man, who I am sure will someday be recognized as one of the greatest mathematicians—yes, intellects—of all time? This theory, presented in 1854, seemed isolated from anything else. Is it by now nothing more than an antiquarian curiosity covered by dust? One likes to think that mathematics and the sciences make up an organic whole. Each branch occupies its own rightful place in relation to all the others. But where do G. Boole's ideas fit in? Are they in part humanities and therefore difficult to integrate fully into modern mathematics and sciences?

4) In trying to learn about how the brain is constructed, I admit that I expended no great effort. It seemed so obvious from wherever I was looking that so much remains opaque about the architecture of the brain that there is absolutely no way in which anything useful can be said about how rational human intelligence propagates in the biochemical platform of the brain. Learning more about the brain seems like a waste of time at present. But it is likely that I will return to the architecture of the brain once the theory of rational human intelligence takes shape.

After all these explorations, inspiration came from an unexpected corner in a most unexpected way. *Electricity*. Why electricity? What does electricity have to do with rational human intelligence? Nothing, I believe. Then how can it be relevant to the

cause of rational human intelligence?

10.4.6. The Next Step: From Electricity in Neurons to Electricity in General

It is easy for students of human intelligence to be attracted to the phenomenon of electricity, even if it is totally unclear at this time exactly how electricity propagates human intelligence in the brain.

Electricity typically first presents itself to students of human intelligence when they turn their attention to the neuron, especially its so-called Action Potential.

Human intelligence is all about the brain. And the brain is all about neurons. And neurons are all about the propulsion of electricity. Therefore, human intelligence ought to be all about the propulsion of electricity, or so it would seem.

It appears that rational human intelligence, like other forms of human intelligence, is propagated by electricity inside the brain in ways that are presently unknown. The question arose in the course of my search for the roots of rational human intelligence: Can a better understanding of electricity perhaps somehow inspire or improve one's understanding of rational human intelligence? I pursued this matter. My unequivocal conclusion is that electricity is irrelevant to the structure of rational human intelligence.

Electricity does serve as the vehicle of rational human intelligence in the brain and brain tissue serves as the biochemical platform of rational human intelligence. There is no denying these facts. But the structure of rational human intelligence has to be established on a different level—not on a *material* level such as electricity or biochemistry but on an abstract physical-mathematical level. Then again, this conclusion came to me as a result of my study of the phenomenon of electricity. How so?

I had originally sought answers about rational human intelligence from electricity. I did not find any. But one possibility would have been to conclude that such answers were not (yet) forthcoming because the brain is at the present time much too imperfectly understood.

However, it became evident in the course of my study of the phenomenon of electricity that such a conclusion is not needed. It appeared to me that a complete physical

and mathematical theory of rational human intelligence is possible. And the principal inspiration came from electricity.

In studying how electricity operates in neurons, it is only natural to try to understand electricity itself a little better. What is electricity in general? In asking this question, the narrow focus on rational human intelligence is abandoned because electricity is everywhere in nature, not only in the human brain. But it will be appear that, while the focus on rational human intelligence is being abandoned at this point, the study of electricity in general will make a return to rational human intelligence possible at a later stage further below.

10.4.7. What Is Electricity?

In search of a definition of electricity, nothing comes more natural to a humanities scholar like myself—and to any newcomer to the subject for that matter—than to look for a book that is entitled *Electricity* or *Electricity: An Introduction* or the like. Likewise, anyone interested in ancient Rome might look for books with the words "ancient" and "Rome" or "ancient" and "Romans" in the title. It appears that it is very difficult to find books with titles in which the word "electricity" is the principal word. There is of course J. C. Maxwell's celebrated two-volume *A Treatise on Electricity and Magnetism* [6]. But "electricity" needs to share space with "magnetism". However, the present interest in electricity has everything to do with interest in the brain. And magnetism does not readily come to mind when one thinks of the operation of the brain, whereas electricity does.

In any event, another tool in which one might look for a simple straightforward statement "Electricity is…" in answer to the question "What is electricity?" is the dictionary. I consulted just two.

In *The American Heritage Dictionary of the English Language* (1981), electricity is defined as "[t]he class of physical phenomena arising from the existence and interactions of electric charge". Charge is measured in coulombs and it is equal to current, which is measured in amperes, multiplied by time. The definition seems terse and adequate. But the newcomer will ask: What is charge? Charge is defined as "[t]he intrinsic property of matter responsible for all electric phenomena…"Apparently, the more basic question is: What is charge? What causes amber (Greek *elektron*) to become charged when rubbed? No one seems to know for sure.

In the fifth edition of the *Shorter Oxford English Dictionary* (2002), electricity is defined as "a property of matter or a phenomenon which manifests itself when substances such as glass and amber are rubbed", etc. Is that property not charge? Charge seems more fundamental than electricity. More on this elsewhere.

All this is rather very general. How to take matters to the next level? There are no introductions to electricity considered all by itself and dictionary definitions of electricity are too short to convey a more precise sense of what electricity is. Then where to look for more information about electricity specifically?

There appear to be two types of manuals in which such information can be found. The first type consists of introductions to electronics. The second type consists of introductions to physics.

The first type, the electronics manual, is concerned with applications of electricity. It teaches one to make things happen by building tools that operate on electricity such as speakers and radios and so on. The second type, the physics manual, is largely theoretical.

It might seem as if the second type is the recommended type for anyone looking for an answer to the question: What is electricity? Then again, the brain itself is in a way a kind of physical tool running on electricity, like a speaker or a radio or also a computer. The student of rational human intelligence might therefore be tempted to assume that viewing the brain as a sophisticated electronics gadget might perhaps be inspiring in constructing the theory of rational human intelligence.

In manuals of electronics, one is very soon introduced to physical materials, such as wires and batteries and resistors. But something is said about electricity in general early on in such manuals.

By contrast, when describing electricity, manuals of physics first turn to concepts such as charge and the electric field and electric potential.

As one reads more and more about electricity, there remains something elusive about it. One has a sense of being nudged into learning matters that are ever more complex while certain basic concepts need to be accepted on good faith without being fully understood. Soon, one cannot resist sensing some of the feeling expressed in the question that is the title of the next section.

10.4.8. What on Earth Is Electricity?

One of my undergraduate students in a hieroglyphics class at Brown University who was also taking physics at the time, Debjani Mitra, who hails from Bangladesh, told me one day: "Everyone talks about electricity but no one tells you what it is". I can sympathize with this sentiment.

What appears to have happened, as was slowly dawning upon me, is that generations of scientists have observed the presence of distinct phenomena such as charge and potential and current and resistance, all empirically different from one another. They have been able to establish the relations between these phenomena after countless investigations. They have made it possible to measure the quantities in which these phenomena come with great accuracy. And they have determined a unit for each type of quantity, in this case the coulomb, the volt, the ampere, and the ohm respectively.

What is more, scientists have established the link between these phenomena and the physics of matter and motion (J. C. Maxwell's designation) involving the three concepts of mass, space, and time as measured by the basic units of the kilo (*k*), the meter (*m*), and the second (*s*).

For example, Work (*W*) or Energy is measured in joules. The unit configuration of the joule is $k \times \frac{m^2}{s^2}$. That is, Work is a mass (*k*) accelerated ($\frac{m}{s^2}$) over a certain distance (*m*). In electromagnetism, Work corresponds to electric charge (*Q*) multiplied by electric potential (*V*).

$$W = QV \, . \qquad (1)$$

A charge is able to do work across a potential. Accordingly, the coulombs multiplied by volts of electromagnetism correspond to $k \times \frac{m^2}{s^2}$ of the physics of matter and motion.

Power (*P*) is measured in watts. The unit configuration of the watt is $k \times \frac{m^2}{s^3}$. That is, Power is a mass (*k*) accelerated ($\frac{m}{s^2}$) over a certain distance (*m*) in a certain time

($\frac{1}{s}$). In other words, in electromagnetism, Power corresponds to potential (*V*) multiplied by current (*I*):

$$P = VI \,. \tag{2}$$

Accordingly, volts multiplied by amperes correspond to $k \times \frac{m^2}{s^3}$ of the physics of matter and motion.

Power is evidently Work over time ($P = \frac{W}{s}$). Watts are joules over seconds. The following alternative definition of what Power is in electromagnetism can be derived by considering Equation (1) above:

$$P = \frac{QV}{s} \,. \tag{3}$$

In other words, volts multiplied by amperes are the same as volts multiplied by coulombs over time. It is also follows from Equations (2) and (3) that

$$I = \frac{Q}{s} \,.$$

A current is a charge over time. Amperes are coulombs over time.

And so on. I pause at these Equations just a little longer because it is not easy for the uninitiated to hunt them down and I wanted to voice a slight degree of frustration in this regard. It is interesting to know how something so fundamental to the human condition as the force of electromagnetism relates in terms of quantity to, say, gravity, in regard to the three fundamental physical dimensions of human existence: space, time, and mass.

As for those who may wonder what place these observations have in a treatise on rational human intelligence, they are the result of my efforts to consider the whole gamut of human experience in order to exclude what is *not* rational human intelligence. And since I consider rational human intelligence to be a phenomenon of physics, contemplating other phenomena of physics seemed like a source of inspiration.

But how much did or do scientists actually know about the true nature of the phenomena whose effects they describe? Then again, it is clear to anyone reading manuals of electronics and physics that one can be perfectly functional without having such knowledge. Experiments show again and again that everything works out nicely. Electricians and electrical engineers are presumably not even all that interested in what electricity actually is.

In descriptions of electricity, the movement of electrons appears to be everything, at least according to the prevailing model. But an elementary inquiry into the history of science readily reveals that the electron was discovered only as late as 1897 by the Nobel Prize winner J. J. Thomson. Yet, there was so much universally recognized progress in the study of electricity in the century or so before 1897. How is this possible?

In this regard, beginning students of electricity may sense a certain relief. In being unable to grasp the true nature of electricity, they suddenly find themselves in some very distinguished company.

Still, the satisfaction that I derived from this observation did not cause me to give up entirely on my pursuit to understand the nature of electricity. I had so far perused manuals of electronics and physics on the high school level. What about the next step up, college level? What about after J. J. Thomson? I read somewhere that J. J. Thomson encouraged anyone approaching a certain problem to at least make an attempt to figure it out for themselves first before reading what others have written about it. Even if one does not succeed, the resulting mind set is beneficial and wholesome. I agree with this observation.

In any event, surely, since J. J. Thomson, since M. Planck, since A. Einstein, since all the developments of quantum theory from the beginning of the twentieth century onward, one would think that scientists must have come much closer to defining the true nature of electricity. The need was for a manual covering the most recent developments in electromagnetism. One would expect an advanced college textbook to document the current state of knowledge.

A Japanese-American, Rei Ukita, was a student of mine in my class on ancient Egyptian literature at Brown University. And that very semester, he also took an introduction to electrodynamics. I asked him about this and he pointed me to the text-

book used in his course, D. J. Griffiths's *Introduction to Electrodynamics* (1999, a reprint with corrections). I acquired it and started perusing it. Clearly, the amount of calculus—what I soon was able to identify as countless partial differential Equations—were far beyond my competence. Yet, I looked around everywhere in this book for inspiration and I believe that I found what I was looking for.

10.4.9. Last Stop and Arrival at Final Destination: J. C. Maxwell's Theory of Electromagnetism and the Theory of Rational Human Intelligence

10.4.9.1. Towards Unification, on the Abstract Level, of J. C. Maxwell's Theory of Electromagnetism and the Theory of Rational Human Intelligence

D. J. Griffiths's afore-mentioned book, in spite of laying out all the advances in electromagnetism, still did not tell me outright what electricity is. I did learn about the existence of divergence and curl in an electric field. Presumably, there are two ways in which any point *A* can move in relation to any point *B*, away and not away. In other words, while moving, *A* can diverge from *B* or, if it does not and still moves, needs to curl around *B*. Combinations of the two are presumably possible. Electromagnetic waves, which propagate through space from one point to another, therefore presumably have the same property.

It is in reading D. J. Griffiths's book that I became first acquainted with J. C. Maxwell's theory of electromagnetism. A number of crucial observations presented themselves to me. They more or less turned upside down my entire way of looking at the problem of rational human intelligence. It suddenly became clear to me personally that the theory of rational human intelligence needs to be of exactly the same type as J. C. Maxwell's theory of electromagnetism. Not only that. Like J. C. Maxwell's theory of electromagnetism, the theory of rational human intelligence can be described completely. And like, J. C. Maxwell's theory of electromagnetism, the theory of rational human intelligence is a theory of physics.

It seemed self-evident all at once that, on a certain abstract level, a kind of grand unification of the theory of electromagnetism and the theory of rational human intelligence was possible.

10.4.9.2. Three Striking Properties Characterizing J. C. Maxwell's Theory of Electromagnetism

Three striking properties characterize J. C. Maxwell's theory of electromagnetism.

First, it is a so-called black box theory. It says nothing about the true nature of the physical events that it describes, in this case electromagnetism. In fact, J. C. Maxwell did not even know what an electron is. The matter is discussed in greater detail in Chapter 4.

Second, the theory is universally regarded as being more or less complete. In fact, it is the *only* theory pertaining to any of the four forces recognized in modern physics—namely 1) gravity, 2) the strong force, 3) the weak force, and 4) electromagnetism—that is essentially complete. In other words, not only does the theory not say anything at all about the true nature of electromagnetism, as noted in the first observation. There is not even any need for it to say anything about electromagnetism. Nor is there even any expectation at this time that it ever will or will have to.

Third, it is evidently a theory of physics, with its own type of mathematics, partial differential Equations being most prominent. Mathematically, the theory owes the most to J.-L. Lagrange. What J. C. Maxwell thought he was doing was to cast M. Faraday's observations in a mathematical language that is much indebted to J.-L. Lagrange. This matter too is discussed in greater detail in Chapter 4. The whole matter is explained in clear terms for a wider audience by B. Mahon in his biography of J. C. Maxwell, *The Man Who Changed Everything*: *The Life of James Clerk Maxwell* (2003). He is quoted more than once in Chapter 4. Has the time come to also change everything in the theory of rational human intelligence?

10.4.9.3. Unifying the Theory of Rational Human Intelligence with the Theory of Electromagnetism: First Step of a Line of Thought Leading from the Latter to the Former, Involving the Concept of the Black Box Theory

How could the theory of electromagnetism possibly be relevant to the theory of rational human intelligence? How could a theory of physics be united, after a manner of speaking, with a theory that pertains to how we think? The two seem so very far apart. It is true that rational human intelligence is propagated by means of electricity in the brain. And the theory of electromagnetism is evidently all about electricity.

The line of thought that led me from the theory of electromagnetism to the theory of rational human intelligence is laid out in what follows.

In any consistent line of argument, every step has to follow from the preceding step. This makes the very first step very important. All the other steps depend on it. Ideally, the first step ought to be an eminently obvious and simple observation that no one can possibly deny.

This first step in question is as follows. In all my afore-mentioned writings on rational human intelligence, which I earlier preferred to call rational thought and language (actually thinking of the term as "rational-thought-and-language", with hyphens reflecting the status of the term as the denotation of a single compound phenomenon), I had always felt uneasy about writing about events whose roots are located inside the brain. It was always clear to me that little or nothing is known about how rational human intelligence operates physically inside the brain.

The result of this concern was the following nagging feeling manifesting itself throughout my investigations: Could it be that all my efforts, published and unpublished, had been provisional or even futile?

It therefore came as a surprise, to say the least, that J. C. Maxwell's theory appeared to be in its entirety a black box theory. As I noted before, this property of the theory is described in detail in B. Mahon's recent biography of J. C. Maxwell, *The Man Who Changed Everything* (2003).

In turning to the history of the study of electricity and the lives of its students, I did what J. C. Maxwell recommends in his *Treatise on Electricity and Magnetism*, referring to the works of M. Faraday, as follows [7]:

It is of great advantage to the student of any subject to read the original memoirs on that subject, for science is always most completely assimilated when it is in the nascent state, and in the case of Faraday's Researches *this is comparatively easy, as they are published in a separate form, and may be read consecutively*.

As has been noted above, what J. C. Maxwell thought he was doing was to give mathematical expression to M. Faraday's experiments.

If I had only looked at the most recent publications relating to electricity, I might have considered the option of taking a couple of years out to comprehend modern

electrodynamics, a task all but impossible in light of other commitments. In any event, it appears that I would have missed what is most essential in the present case. My turn to history had an unexpected and happy outcome.

For about 13 years, I had off and on published on topics that pertain to what I now prefer to call rational human intelligence. These publications pertain to events of language whose roots inside the brain cannot be observed. The question was always present in my mind: Is it justified to present theories of events whose true physical nature cannot be determined or observed? Now it appeared that something like this had already been done before. And no less in one of by far the most celebrated theories of physics of all time.

It soon also appeared that the theory of gravity is likewise a black box theory because no one really knows what gravity is. But the analogy between the theory of electromagnetism and the theory of rational human intelligence is much closer. First, both involve electricity. Second, both can be inside an object, in the case of electromagnetism in an engine or a wire or a magnet, in the case of rational human intelligence inside the brain. Third, both explain how electricity operates inside an object without it being necessary to look inside the object; what one observes is what comes out of the object, observable and measurable waves and related effects in the case of electromagnetism and language in the case of rational human intelligence; the difference is that the theory of electromagnetism is about electricity itself whereas rational human intelligence is about something propagated by electricity.

By contrast, gravity permeates the entire universe causing everything to attract everything else in a certain way. It makes for less of a suitable analogy.

If it is to exist at all, the theory of rational human intelligence at the present time simply must be a black box theory. Practically nothing is known about how the brain operates when it generates rational human intelligence. My own conviction is that a black box theory of rational human intelligence is possible. In fact, all my work on rational human intelligence to date implies as much.

But does the resulting identity between the theory of electromagnetism and the theory of rational human intelligence suffice to speak about some kind of a grand unification of the two on an abstract level? More is needed to justify such unification, one would think. In fact, there is more. And clearly enough, I believe, to view the theory of electromagnetism and the theory of rational human intelligence as a peculiar

kind of twins.

The theory of electromagnetism and the theory of rational human intelligence are identical in two other fundamental ways, in addition to both being black box theories. They both are, 1) complete (though in the case of rational human intelligence still in need of full description), and they are, 2) theories of physics with a characteristic brand of mathematics. These two properties are discussed next.

10.4.9.4. Unifying the Theory of Rational Human Intelligence with the Theory of Electromagnetism: Second Step of a Line of Thought Leading from the Latter to the Former, Involving the Completeness of Both

The black box property, which the theory of electromagnetism exhibits and which—I am convinced—the theory of rational human intelligence exhibits just as much, may not have been the first property of the theory of electromagnetism to draw my attention.

I was also early on impressed by the fact that the theory is generally considered to be more or less complete and at the same time surprised and even a little perplexed that, in spite of being complete, the theory still did not tell me what electricity is. It may have been at this point that the black box property came into focus. The property accounts in a way for the fact that the theory does indeed say nothing about the physical phenomenon whose laws it describes.

I had located what all consider to be the final explanation of how electricity behaves and I was still not told what electricity is. What is more, I was not in bad company. No one else seemed to know what it is. Even J. C. Maxwell had no idea. Then why worry? Electricians are not worrying. Electrical engineers are not worrying. In fact, nobody seems to care.

The question arises: Can the theory of electromagnetism and the theory of rational human intelligence be brought even closer together in that the latter is as complete as the former? Rational human intelligence needs to be described as part of a black box theory. But is it possible to describe all of rational human intelligence in this manner?

Two considerations soon convinced me personally that a complete theory of rational human intelligence is already at this time possible, no doubt about it, even if the

theory still needs to be described in full.

The first consideration concerns rational language issuing from the mouths of speakers or from the pens (or keyboards) of writers. Nothing seems more obvious to me than that such language accurately reflects the rational human intelligence inhabiting the brain.

If this were not the case, then we might on occasion be saying something that differs in purport from what our brain is thinking that it is saying. The result would be utter chaos in the verbal communications between human beings. However, human beings generally have the impression that what their mouths are saying reflects what is inside their brain and that they can express all that they are rationally thinking by means of rational language. It is therefore possible to make inferences about all of rational human intelligence inside the brain from what comes out of the brain in terms of language.

The second consideration concerns my own prolonged study of language. I have published on grammar and linguistics, have written part of a grammar of ancient Egyptian, and have learned how to read, if not write and speak, a number of languages. In the course of all this study, I have been able to pass in review all that the structure of language has to offer. Drawing from this experience, I identified all the flavors of rational human intelligence that I could find. I called them Contrast Digitality, Selection Digitality, Nexus Digitality, Certification Digitality, and Supplement Digitality. At some point, I could find no more flavors, however hard I looked. I am not entirely excluding that I might find more. But I strongly doubt it. Then again, there may be fine tuning of the description of the flavors that I did find.

It was my acquaintance with the theory of electromagnetism, a black box theory that is complete, that enabled me to muster the courage to assume that I had found all the flavors and that the theory of rational human intelligence can also be a black box theory that is fully complete. The full description of each of the flavors is still lying ahead. I fully intend to produce it.

In the same way, J. C. Maxwell's theory of electromagnetism describes all that anyone had been able to find in terms of electromagnetic effects. At some point, all effects had been located, so it seemed (no one since has ever been able to find any additional ones after looking everywhere), and the black box theory of electromagnetism accounts for all of them more or less to exhaustion.

In that same way, I cannot imagine that I will find anything else, even if I am not entirely excluding the possibility. Language is a finite phenomenon. There are only so many places to look. Still, some fine tuning of what I did find will be needed.

Before coming to the firm conclusion that the theory of rational human intelligence can be complete, a related notion had already occupied me for quite some time. It was the notion of the possibility of the final definition of a linguistic phenomenon pertaining to rational human intelligence. In books and articles cited above, I proposed a number of what I believe to be final definitions of certain linguistic phenomena in terms of rational human intelligence. It was my impression that the definitions left nothing to be explained about the phenomena in question because the limits of understanding had been reached.

The notion of finality is closely related to the notion of completeness. Both imply that there is nothing more to do. There is no beyond. The difference between the two is that finality pertains to *parts* of rational human intelligence, that is, to certain specific phenomena of rational human intelligence. Completeness pertains to *all* of rational human intelligence. A complete theory of rational human intelligence is one that provides final definitions of all phenomena pertaining to rational human intelligence.

Whence the notion of finality? It had always been evident to me—and I assume that everyone would readily agree—that there are certain things that the brain can do and certain things that the brain cannot do in terms of rational human intelligence. Accordingly, there ought to be a precise line somewhere that separates what the brain can do from what the brain cannot do. But where is that line?

The design of my earlier studies of rational human intelligence was to reveal sections of that line. The design of a complete theory of rational human intelligence is to describe the entire line.

10.4.9.5. Unifying the Theory of Rational Human Intelligence with the Theory of Electromagnetism: Third Step of a Line of Thought Leading from the Latter to the Former, Which Involves the Fact That Both Are Theories of Physics, Sealing the Unification

What does it mean to unify two theories, in this case the theory of electromagnetism and the theory of rational human intelligence? It seems to me that unification in the

present case involves establishing the fact that the two theories share properties that, when they are all taken together, set the two theories apart as a pair from all the theories known at this time.

The focus is on the theory of electromagnetism and the theory of rational human intelligence. What are the properties that set these two theories apart as a unique pair? The fact that not only the theory of electromagnetism but, as I firmly believe, also the theory of rational human intelligence is a black box theory contributes much to making the two very similar—though not uniquely similar because the theory of gravity, say, is also a black box theory. The black box property is otherwise critically important to the theory of rational human intelligence. Without it, the theory is not in the least possible as hardly anything is known about how rational human intelligence operates in the brain.

The fact that the two theories in question are both complete as black box theories brings them much closer, with the theory of rational human intelligence being still in need of a full description (which I intend to present). I am not aware of any other theory that is quite like these two in regard to these two properties.

I had been studying rational human intelligence for more than a decade without assuming the presence of either property. My conclusion, reached all at once, that both properties are very much present evidently deeply changed my perspective on what it is that I think that I am doing. The change was even much more radical when, around the same time, it also suddenly occurred to me that yet a third property is present. The inspiration that led to diagnosing the presence of this property came again entirely from J. C. Maxwell's theory of electromagnetism.

The theory of electromagnetism is a theory of physics with its own particular brand of mathematics. I became convinced all at once that the theory of rational human intelligence is likewise a theory of physics with its own particular mathematics. The mathematics of electromagnetism is a branch of quantitative mathematics, that is, that which all think of as mathematics in general. By contrast, the mathematics of rational human intelligence is not quantitative. Nothing gets bigger or smaller. It is the digital mathematics first described in full by G. Boole. But G. Boole did not observe all the ways in which the mathematics of rational human intelligence finds expression in the physics of rational human intelligence. There is no mention at all of what I call Certification Digitality and Supplement Digitality. The description of rational human intelligence is not complete without them.

I personally very much insist on calling the theory of rational human intelligence a theory of physics. I strongly suspect that physics may well be one of the very last fields that anyone would ever have assumed that the theory of rational human intelligence belongs to.

Why such insistence on physics? The brain is a physical tool. It is not a mechanical tool but a biochemical tool. Still, it is a physical tool that operates in certain ways. One of these material operations is rational human intelligence. The laws that govern the material operation of rational human intelligence are the mathematical laws formulated first and for the most part by G. Boole.

As I noted above, I had now arrived at a critical juncture. All at once, it made sense to me personally, as I have noted before,

1) what I was doing (physics),
2) that what I was doing was possible (as a black box theory), and
3) that I could do all of it (just as the theory of electromagnetism does).

This changed everything. The description of rational human intelligence is forthcoming in a number of installments. Let others judge what to make of them once they are ready.

I suspect that, over the years, many a colleague of mine has wondered at—or been puzzled by—what I was doing and where it was supposed to lead. My writings about the matter in question have met mostly with silence. No one has explicitly condemned the efforts, as far as I know, at least not so far, and for that I am grateful.

Considering the silence, I cannot say that what I wrote was born out of any discussions or exchanges of mind. It has been a solitary effort, evidently inspired deeply by the work of learned people of the past whose ideas I chose to follow after much consideration. The careful selection of these people has always been a matter of great concern to me as I acquainted myself as much as possible with what had been done on the subject of human intelligence across the centuries if not millennia. Many of most of the works that I have consulted on the topic of human intelligence in many disciplines all the way back to antiquity are not mentioned here. But I have looked in many, many places. However, in the end, this effort is physical and mathematical. And like any mathematical effort, it is in need of a sparing argument in which—at every step—only what is needed, nothing more nothing less, is brought to bear.

Perhaps, G. Boole thought that he was doing mathematics, not physics. But then, the distinction was not as sharp in his time as it is now. B. Russell somewhere famously stated that G. Boole invented pure mathematics. I do not think that this is true. G. Boole for the most part did invent a kind of mathematics, which I have elsewhere called digital mathematics or also attribute mathematics. What sets G. Boole's mathematics apart from what is generally considered mathematics is not that it is pure, but that it is non-quantitative.

10.5. "Lagrangian"

10.5.1. From J. C. Maxwell to J.-L. Lagrange: The Origin of a Second Major Influence of the Physics of Matter and Motion on the Proposed Complete and Final Theory of Rational Human Intelligence

I have described above at length how my engagement with the theory of rational human intelligence owes much—though in a kind of serendipitous way—to J. C. Maxwell's theory of electromagnetism. The contemplation of the latter theory changed everything about my approach to the former theory—though without, I believe, subverting any of what I had done previously. J. C. Maxwell's influence is discussed at greater length in Chapter Four. The influence from J. C. Maxwell is something that I have dealt with in the past. Still, it seemed useful to recapitulate the main facts in the present retrospective. In fact, in the course of writing this retrospective, I believe that I have been able to make the matter much more clear to myself as to how these main facts are precisely relevant, especially in regard to what changed seemingly everything in my contemplation of rational human intelligence at the end of 2012.

Meanwhile, since the end of 2012, another fundamental influence and inspiration has taken root. This inspiration came in the summer of 2014. And I wish to report on it. The design of the Preface that follows is to describe this second, and new, influence. In short, this influence involves the notion that all of rational human intelligence can be derived from just one single principle. All of it. From one principle. How so?

This second new influence does not directly hail from J. C. Maxwell but from J.-L. Lagrange, perhaps the keenest mathematician of the eighteenth century. Then again, J. C. Maxwell is not entirely out of the picture because the path to J.-L. Lagrange led

straight from J. C. Maxwell.

I had been aware that, in his writings, J. C. Maxwell explicitly defined much of what he accomplished in electromagnetism in its relation to the works of, 1) M. Faraday and, 2) J.-L. Lagrange.

On the one hand, he felt that what he had done in his *Treatise* was to give mathematical expression to M. Faraday's far-reaching experiments in electricity and magnetism. He states that much in clear terms, as follows [7]:

I have confined myself almost entirely to the mathematical treatment of the subject, but I would recommend the student, after he has learned, experimentally if possible, what are the phenomena to be observed, to read carefully Faraday's Experimental Researches in Electricity. *He will there find strictly contemporary historical account of some of the greatest electrical discoveries and investigations, carried on in an order and succession which could hardly have been improved if the results had been known from the first, and expressed in the language of a man who devoted much of his attention to the methods of accurately describing scientific operations and their results…*

If by anything I have here written I may assist any student in understanding Faraday's modes of thought and expression, I shall regard it as the accomplishment of one of my principal aims—to communicate to others the same delight which I have found myself in reading Faraday's Researches.

On the other hand, J. C. Maxwell felt that he owed much if not most in regard to what was needed directly for the task at hand in terms of mathematical models to J.-L. Lagrange. That much is obvious from the following quote [8]:

553.] *In the fourth section of the second part* [*of Volume* 2] *of his* Mécanique Analytique, *Lagrange has given a method of reducing the ordinary dynamical equations of the motion of the parts of a connected system to a number equal to that of the degrees of freedom of a system…*

As we shall find it necessary, in our endeavors to bring electrical phenomena within the province of dynamics, to have our dynamical ideas in a state fit for direct application to physical questions, we shall devote this chapter to an exposition of these dynamical ideas from a physical point of view…

554.] *The aim of Lagrange was to bring dynamics under the power of the calculus.*

10.5.2. J.-L. Lagrange's *Mécanique analytique* and His "Principle of Virtual Velocities", Now Commonly Known as the Principle of Virtual Work

It was J. C. Maxwell who led me to J.-L. Lagrange. The reason is that J.-L. Lagrange's mathematics to a considerable extent made the construction of the theory of electromagnetism as a black box theory possible. B. Mahon also stresses this fact in his biography of J. C. Maxwell [9].

At the same time, J. C. Maxwell drew my attention to the importance of J.-L. Lagrange's *Mécanique analytique* (J.-L. Lagrange wrote "*Méchanique analitique*"), a work that was otherwise not entirely unknown to me. It has been common to place J.-L. Lagrange's *Mécanique analytique* on the same lofty level in terms of importance as I. Newton's *Principia*, published just about a century earlier, and therefore on the same level as J. C. Maxwell's *A Treatise on Electricity and Magnetism*. In light of the eminent importance of the *Mécanique analytique*, it seemed worthwhile to see what it is all about.

It soon appeared that the most fundamental property of J.-L. Lagrange's *Mécanique analytique* is not mentioned explicitly by either J. C. Maxwell or his biographer B. Mahon. The fact is after all not directly relevant to the theory of electromagnetism. This may explain why my becoming aware of the relevance of J. C. Maxwell's theory, on an abstract level, to the theory of rational human intelligence in late 2012 predates by some time my becoming aware of a similar relevance on the part of J.-L. Lagrange's *Mécanique analytique* in the summer of 2014.

What is this truly remarkable property?

The property in question is that, as is now universally acknowledged, all of the mechanics described in the *Mécanique analytique* is derived from one single principle of physics, just one. J.-L. Lagrange called this principle the "Principle of Virtual Velocities". It is now generally called the Principle of Virtual Work. It is in fact now generally accepted that "Principle of Virtual Velocities" is a bit of a misnomer.

J.-L. Lagrange's physics is quite advanced. It is not normally part of average college physics courses. It is therefore beyond my competence to understand the "Principle of

Virtual Velocities" properly. And since velocity has everything to do with quantity and rational human intelligence nothing, a thorough understanding of the principle would not contribute to a thorough understanding of rational human intelligence. It would therefore be unwise for me to take a detour of years to try to get to the bottom of it, if I ever could.

J.-L. Lagrange shared with J. C. Maxwell a keen interest in the history of physics as well as the conviction that such interest always sheds light on one's understanding of the most modern advancements. Accordingly, J.-L. Lagrange at length places the principle in its historical context in the *Mécanique analytique*.

As to what the "Principal Virtual Velocities" exactly is. Just for completeness' sake, I cite two definitions that J.-L. Lagrange gives of the principle at hand, namely as [10] *the velocity which a body in equilibrium would take if the state of equilibrium ceased to exist, that is, the velocity that the body would have in the first instant of motion,* and also as follows [11]:

[*The principle*] *can be expressed in a more general manner*: *If an arbitrary system of any number of bodies or mass points, each acted upon by arbitrary forces, is in equilibrium and if an infinitesimal displacement is given to this system, in which each mass point traverses an infinitesimal distance which expresses its virtual velocity, then the sum of the forces, each multiplied by the distance that the individual mass point traverses in the direction of this force, will always be equal to zero. Furthermore, the small distances traversed in the direction of the forces are considered positive and the distances traversed in the opposite direction are considered negative*.

J.-L. Lagrange first accepted the principle at hand as the foundation of the analysis of mechanics in 1764 in a memoir on the theory of libration of the moon, adopting it instead of the Principle of Least Action [12].

A young J.-L. Lagrange, while still in his native Turin, had in 1758 propelled calculus to new unprecedented heights by means of his Calculus of Variations, the most fruitful expansion of calculus since I. Newton and G. W. Leibniz.

It is natural for outsiders to wonder how such a complex edifice described in the *Mécanique analytique* across hundreds and hundreds of pages could be based on a single principle. It almost seems like magic.

There is no connection of any kind between the Principle of Virtual Work and

rational human intelligence. Then how could the specific role that the Principle of Virtual Work plays in the *Mécanique analytique* be at all relevant to the theory of rational human intelligence? The matter is discussed next.

10.5.3. The Relevance of J.-L. Lagrange's "Principle of Virtual Velocities" to the Theory of Rational Human Intelligence

As was noted above, inspiration derived from J. C. Maxwell's theory of electromagnetism made it clear to me personally all at once

1) what I had been and was doing (physics),

2) that what I was doing was possible (for the time being as a black box theory), and

3) that I could do all of it (just as J. C. Maxwell's theory does for electromagnetism).

So I embarked on the complete and final description of the theory of rational human intelligence. I had been doing a good deal of said description in bits and pieces for years in widely scattered publications cited above, though without knowing what exactly it was that I was doing and while using a provisional terminology.

How so: a complete and final description? How can this be?

For many years now, I have persistently looked everywhere I could in language for manifestations of rational human intelligence. As I noted above, I believe to have found all such manifestations, though some fine tuning of my findings may be necessary as a detailed description proceeds. As a result, as far as I can see at this time, rational human intelligence comes in five flavors, already mentioned above:

1) Contrast Digitality (ConDi);
2) Selection Digitality (SelDi);
3) Nexus Digitality (NexDi);
4) Certification Digitality (CerDi); and
5) Supplement Digitality (SupDi).

I have a fairly clear picture of my understanding of these five types of digitality.

But a full account still needs to be delivered.

The following consideration also favors the possibility of a complete theory of rational human intelligence. In my work on prime numbers—which is cited above in Section 2—and in other writings, I dealt at length with the notion that there are absolute limitations to rational human intelligence. Who could possibly disagree with the notion that there are things that the brain can do and things that the brain cannot do? Consequently, there has to be a line somewhere. It follows that the ground that needs to be covered in describing rational human intelligence is subject to said limitations. In other words, there is an end to it. And it should therefore be possible to describe all of it. I have no doubt that it can be.

I had become convinced—inspired in part by J. C. Maxwell's theory of electromagnetism—that the theory of rational human intelligence needs to be a theory of physics. The brain is a physical tool and rational human intelligence is something that physically happens to it. Rational human intelligence simply must be a physical process.

But how exactly do the proposed five flavors of digitality together form a theory of physics of all things? Physics? And what exactly does this theory of physics look like? Certain factors led me to conclude that the theory of rational human intelligence, as a theory of physics, exhibits the same overall structure as J.-L. Lagrange's theory of mechanics expounded in his *Mécanique analytique*. A certain unification of the *Mécanique analytique* and the theory of rational human intelligence on an abstract level therefore appears possible. How so?

The recognition of the possibility of a certain unification between the two theories came in the context of two earlier developments.

First, I had already postulated quite a while back that all of rational human intelligence is digital. I always was aware that this is a view that might run into strong opposition. Nevertheless, I just went on to propose that the digitality of rational human intelligence comes in five flavors. They have already been mentioned above. Accordingly, the five flavors appear to be five ways in which a single principle is manipulated or exploited. Or, all five flavors derive from a single principle.

Second, more recently I had come to the conclusion that the theory of rational human intelligence is a theory of physics.

Against the background of these two developments, two striking similarities between the theory of rational human intelligence and J.-L. Lagrange's *Mécanique analytique* presented themselves to me more or less simultaneously in the summer of 2014.

First, the principle of digitality plays the same role in the former theory as the "Principle of Virtual Velocities" does in the latter theory. All else is derived from it.

In this regard, it is interesting to observe that G. Boole's earliest published mathematical work was inspired by precisely by this derivation [13].

Second, both theories are theories of physics.

The missing element is the precise nature of digitality. The "Principle of Virtual Velocities" is a principle of physics. For the two theories to be identical in overall structure, digitality ought to be a principle of physics as well. If it is, then in both cases an entire theory of physics is derived from a single principle of physics. And unifying the two theories would then be altogether justified.

In the popular imagination, digitality is in general associated with computers, more specifically with the contrast between 1 and 0 or between On and Off, with relays that are either open or closed or transistors that either do or do not conduct electricity, in short, with most anything that exists in two and only two states. It would be seem as if all digitalities are the same. But that is definitely not the case, though no one seems to have ever systematically and with precision distinguished between different types of digitality. The present argument is concerned with one type of digitality, the one that pertains to rational human intelligence. I hope to compare the digitality of rational human intelligency and other modes of digitality elsewhere.

When it comes to rational human intelligence, digitality ought to be a principle of physics. What does it take to be a principle of physics? For example, what makes the "Principal of Virtual Velocities" a principle of physics? It is a principle of physics because it pertains to the properties of bodies or mass. It relates mass to space and time. It is all about matter and motion.

J. C. Maxwell did much to codify the units of physics in his time. He was a pioneer in this respect. He considered mass, space, and time to be the three basic dimensions of physics, as measured in kilos (*k*), meters (*m*), and second (*s*). More detail regarding

this matter is to be found in Chapter Four.

Little was J. C. Maxwell aware that bodies or mass exhibit yet another fundamental property. The property does not show up in any theories of physics. Yet, it is fundamental to an understanding of rational human intelligence. In fact, rational human intelligence consists entirely of the manipulation and exploitation of this property. I have called the property attributivity. Attributivity is described in greater detail in Chapter 4.

The design of the following Preface is to define digitality as a single principle of physics from which all of rational human intelligence is derived. It is then specified how the five flavors of digitality are derived each in their own way from the single principle of digitality. The description of the flavors is somewhat provisional as I hope to describe each of them in full detail elsewhere.

11. A Concluding Note Regarding the Relation between Calculus and the Theory of Rational Human Intelligence

As my investigations of rational human intelligence evolved, it always seemed possible that calculus would play a role. It plays an enormous role in the physics of matter and motion, what everyone considers to be physics in general. Calculus is everywhere. As a non-mathematician, I began reacquainting myself with the principles of calculus on the assumption that calculus might be relevant. It appears that calculus is definitely not relevant to the cause of rational human intelligence.

It goes without saying that, if a highly sophisticated calculus would have been relevant to the description of rational human intelligence, a significant detour would have been necessary, perhaps a detour that would be difficult to surmount in terms of both complexity and time commitment.

But as it turns out, calculus is not relevant in the least. In a way, that was a relief. The main reason is that calculus is all about quantity. More specifically, it is all about describing rates of change in quantity over time, as when a car speeds up or slows down. By contrast, the digital mathematics that acts as the operating system of rational human intelligence has nothing to do with quantity at all.

Calculus has played such a crucial role in the achievements of the human mind. The question arises: How could it somehow not relate to rational human intelligence? The answer is: Calculus is part of knowledge and not of what I would call rational human intelligence. In fact, the vast majority of people know little or nothing about calculus. How could they all be incapable of rational thought?

12. Some Remarks on Open Access Publishing

The fact that the present book is published in Open Access mode invites reflections about the movement. The Open Access model provides free and easy access to any and all interested across the globe. And Scientific Research Publishing (SCIRP) is able to do it with great—and ever improving—style and professionalism in all conceivable mediums, hard copy, epub, PDF, html, and so on.

The Open Access model generates much controversy. There are those that ardently defend it. And there are those that virulently oppose it, yes absolutely condemn it. There is no denying the fact. Nor is there any denying the fact that Open Access publishing, in the end, constitutes a mixed bag. And there have even been some outright disasters. But I refuse to believe that Open Access is all bad. In fact, the established model of restricted access and gatekeeping has had its own large scale scandals in recent times, some of them highly publicized.

In the end, Open Access is a model that allows everyone without exception to judge for themselves without restrictions or handicaps about the validity of a certain intellectual product.

And when it comes to the business model, big companies—yes, corporations—like Cambridge University Press and Elsevier need to make money too.

Open Access is something that is much less easy to control than restricted access publishing. In that regard, it is like the Internet itself. In fact, it is a kind of inevitable product of the Internet age. One might even ask oneself: How could something like Open Access *not* have come into existence sooner or later?

One of the many advantages of Open Access is that it allows all developing nations across the world to participate in the intellectual engagement with the whole range of scientific topics. There will be growth pains. But I am personally confident that, over

time, by some kind of complex historical process, what is good will rise to the top and what is bad will sink to the bottom. And no gatekeepers will commandeer this process.

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