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A Multi-Perspective Approach to a Theory of Knowledge

Bill Seaman[1]

Review of M. Burgin (Series Editor, Volume Author), World Scientific Series in Information Study: Vol. 5. *Theory of Knowledge, Structures and Processes.* Singapore: World Scientific. 966 pp., ISBN-10: 9814522678, USD $128.25.

Mark Burgin has put together a comprehensive body of research to articulate this particular theory of knowledge. One immediately sees that Burgin has been developing ideas related to this book for over 47 years. He provided me with this short text to help frame the major foci in the book. I have also worked with parts of his introduction to follow his articulate logic of progression through the chapters.

Basic Features

Or, how this book stands out from existing publications.

1. The book unifies knowledge about knowledge from three areas: epistemology (philosophy), artificial intelligence (information technology), and knowledge management (social structures).
2. Usually knowledge is considered only on one level—the conventional mundane and formalized, for example, in logic, knowledge of people. In the book, two other levels are introduced and studied: quantum knowledge and global knowledge. As a result, knowledge is studied on three levels.
3. The basic condition in the classical/conventional logic is consistency. The book describes how logic can be used to represent and utilize inconsistent knowledge, which is essentially important because knowledge of individuals and society is mostly inconsistent.
4. The theory of quantum knowledge is developed.
5. The theory of global knowledge is developed.
6. The highest level of formal logic—logical varieties, prevarieties and quasi-varieties—and its applications are presented.
7. A brief history of knowledge studies in Eastern cultures (China, India) is presented.
8. The level of metaknowledge is studied.
9. Relations between information, knowledge and data are analyzed and clarified.[2]

1. Email: bill.seaman@duke.edu
2. Personal email provided by the Mark Burgin.

Burgin is well aware of the breadth and depth of the field and provides an incredibly well read and extremely broad set of references, often drawing from his own research history. He points out that:

> It is necessary to remark that the research in the area of knowledge studies and applications is active, while knowledge is related to almost everything. Consequently, it is impossible to include all ideas, issues, directions, and references to materials that exist in this area, for which we ask the reader's forbearance. [p. 43]

The book is at moments highly technical. It explores both quantitative and qualitative approaches to pointing at knowledge production from many different vantage points. He states:

> Exposition of material is aimed at different groups of readers. Those who want to know more about history of knowledge studies and get a general perspective of the current situation in this area can skip proofs and even many theoretical results given in the strict mathematical form. At the same time, those who have a sufficient mathematical training and are interested in formalized knowledge theories can skip preliminary deliberations and go directly to the sections that contain mathematical exposition. Thus, a variety of readers will be able to find interesting and useful issues in this book if each reader chooses those topics that are of interest to her or to him. [p. 42]

Related to his above list of foci Burgin states in the preface:

> - AI is typically directed at knowledge representation and processing.
> - Epistemology is largely interested in knowledge definition and acquisition (cognition)
> - Knowledge management is mostly concerned with knowledge organization and utilization.
>
> In addition, knowledge is also explored in psychology, sociology, and linguistics [p. x].

Burgin lays out a broad ground plan for the book and how it relates to a multitude of publications across this field of fields:

> So why is this book different? It is different because its main goal is to present, organize, and synthesize the basic ideas, results, and concepts from these three directions, which are loosely related now, into a unified theory of knowledge and knowledge processes. It is called the synthetic theory of knowledge. It is multidisciplinary and transdisciplinary at the same time. The approach presented in this book provides a new explanation of important relations between knowledge and information demonstrating new kinds of possibilities for knowledge management, information technology, data mining, information sciences, computer science, knowledge engineering, psychology, social sciences, genetics, and education that are made available by the synthetic theory of knowledge.
> —How knowledge is related to information and data?
> —How knowledge is modeled by mathematical and logical structures?
> —How these models are used to better understand and utilize computers and the internet, cognition and education, communication and computation? [pp. x, xi]

This bringing together of multiple intellectual perspectives and talking across fields to create new understandings, brings to mind the Macy Conferences as a specific historical site for knowledge production. The proceeding of those conferences are now housed in a book authored by Claus Pias (2004) and also offer a set of cybernetic perspectives related to transdisciplinary knowledge production.

Burgin's basic theory states the following:

> Knowledge is inseparable from information. People acquire knowledge receiving cognitive information. At the same time, knowledge, by its essence, contains information and this is the main feature of knowledge. This intrinsic unity of knowledge and information forms the base of the synthetic theory of knowledge. [p. xi]

Burgin defines and builds a comprehensive architecture related to each of these above-mentioned areas. He constructs an erudite building of ideas, thoughts and approaches. Thus, the book embodies an unfolding understanding of knowledge processes, continuously articulating and composing this multi-perspective theory of knowledge. Thus, in part, it enacts what it is itself talking about—knowledge production. In so doing, he houses many perspectives and relational ideas through the construction of many adjacent thought architectures. He builds his arguments carefully and often one argument plays into the understanding the next and the next. In many ways, these composite ideas span the length of the entire book. Yet, to be clear, he often points out contradictions and differing perspectives related to the authors cited. The book is packed with quotes and historical facts and often points to the set of differences that multiple scholars, philosophers, historians, mathematicians, and others bring to the table. He is good with providing definitions where possible, yet ironically, he points to the difficulty of providing a singular definition for knowledge. He states:

> However, knowledge is not an easy concept to understand. As Land et al. (2007) write, knowledge is understood to be a slippery concept which has many definitions. This is apparent in the many questions philosophers and other thinkers ask themselves about the essence, distinctive characteristics, functions and roles of knowledge in society. These questions can vary from theoretical considerations to practical applications. [p. 6]

In his chapter exploring a brief history of knowledge studies [p. 9], the author interestingly brings in a history of both Western and Eastern philosophical perspectives. He also includes a history of logic and specific aspects of relevant mathematical concepts. These are fascinating in their relationality. An extremely important point is that Burgin thus leaves the reader to make up their own definition of knowledge drawing from their multi-perspective observations as they relate to an individual's own set of perspectives—their own mindset. As an artist, and media theorist, as well as someone deeply interested in the history of computation and computational creativity, it was also interesting for me that he pointed to knowledge production as it relates to the arts.

> Art can convey representational and operative knowledge. Indeed, on the one hand art is a representation of different things. It can imitate (represent or reflect) states of the external world—nature, people, society etc., as well as the inner state of the artist. "Art as a representation of outer

> existence (admittedly "seen through a temperament") has been replaced by art as an expression of a humans' inner life'" (Worth 2010). In such a way art gives representational knowledge. On the one hand art can teach people providing models of different actions, behavior, and attitudes. In such a way, art gives operational knowledge. [p. 50]

Burgin speaks at length about intuition as one set of perspectives related to knowledge production. He brings up intuition much later in the book in the chapter entitled "Intuition as a Cognitive Instrument":

> Parsons (2008) distinguishes *intuition of* from*, intuition that.* For instance, it is possible to have an *intuition of* a straight line in the Euclidean plane without an *intuition that* given any straight line and any point beyond this line, there is one and only one strait line parallel to a given straight line. [p. 675]

Burgess (2014) contemplates mathematical intuition as a kind of rational intuition with three forms:

> —The set-theoretic intuition is intuition related to set-theoretic concepts.
> —The geometric in the sense of Gödel, intuition supports the belief that the three-dimensional Euclidean space correctly represents a certain structure existing in the realm of mathematical objects.
> —The chronometric intuition is intuition related to time. [p. 676]

In addition Burgess separates two forms of empirical geometric intuition:

> —The *spatial* intuition supports belief about physical space.
> —The *temporal* intuition is related to physical time. [p. 676]

Bunge (1962) suggests many more types of intuition, which are named and listed below:

1. *Perceptual intuition* is immediate identification of a thing, phenomenon or symbol.
2. *Comprehension intuition* is clear understanding of the meaning and/or interrelations of system of symbols such as a text or a diagram.
3. *Interpretation intuition* is easiness of interpretation of conventional signs and symbols.
4. *Geometrical Intuition* is the ability to envisage absent things and construct visual models and schemas.
5. *Metaphoric Intuition* is the ability to apprehend and develop metaphors.
6. *Creativity intuition* is interpreted as creative imagination.
7. *Reasoning intuiti*on is the ability to easily synthesize different elements, systems, and objects in a unified system.
8. Common sense intuition is the ability to make decisions without utilization of scientific knowledge or sophisticated reasoning.
9. Practical intuition is the ability to make sound judgments and estimates. [p. 677]

Burgin goes on to point out that there are three types of intuitive knowledge/information production:

— Analogy;
— Extension or generalization;
— Guessing. [p. 677]

Although I am interested in the many forms of knowledge production that are pointed to in Burgin's book, as an artist I am deeply interested in intuition in terms of art production. Yet, many of the above foci fall into the creation of new forms of algorithms that function in the service of making art by crossing disciplinary boundaries, and in so doing can also point at new knowledge, especially through the exploration of the potentials of computational creativity explored via intuition.

Burgin, in a highly adept manner points out:

> The main goal of the book is to achieve a synthesized understanding of the complex multifaceted phenomenon called knowledge by building a general theory of knowledge, which allows systematizing and binding together existing approaches to knowledge in one unified theoretical system. [p. 39]

He is careful in the book to point at the limits of his study and research, and perhaps the vastness of this field of fields.

> However, we do not try to represent all approaches and directions of knowledge studies in a complete form or even to give all important results of this area. Our goal is to give an introduction to the main approaches and directions, explaining their basics and demonstrating how they can be comprehended in the context of the general theory of knowledge. Besides, references are given to sources where an interested reader can find more information about these approaches and directions of knowledge studies. The goal is to present a broad picture of contemporary knowledge studies, provide a unifying theory of knowledge and synthesize all existing approaches in amalgamated structure of ideas, constructions, methods, and applications. [p. 39]

I will now give a breakdown to the chapters and try to point at some of the more interesting aspects of these sections from my perspective.

The Chapters

Chapter 1

In Chapter 1, Burgin explores "the leading role of knowledge in contemporary society and describes a brief history of knowledge studies in different countries and cultures exhibiting not only the development of knowledge studies in Western countries but also achievements of the Eastern civilizations in the field of logic" [p. 40].

I find this historical research of great interest. Burgin outlines his multi-perspective approach by articulating a particular set of three overarching theories, including "Philosophical theories, Mathematical theories, and Empirical Theories" [p. 2]. He articulates that in the area of knowledge these can be divided and studied via three basic approaches: structural analysis, axiological analysis—knowledge that "aims at explanation of those features that are primary for knowledge as a social and technological phenomenon" [p. 3], and functional analysis —"how knowledge tries to find how knowledge functions, how it is produced and acquired" [p. 3]. It is here perhaps interesting to ask a question related to this chapter. How is that one decides which historical philosophic logic to follow, or look back at with deeper interest? Is this also related to the domain of interest of the reader and their given background, as it intersects with the mindset of the author?

Chapter 2

In Chapter 2, Burgin studies properties of knowledge and its classifications: "In this book, we treat knowledge in the more general setting, namely, in the context of epistemic structures" [p. 40].

Burgin discusses the notion that there are three basic categories of knowledge: "Representational knowledge about an object is representations of this object by knowledge structures, such as models and images" [p. 48]; Descriptive knowledge, "also called declarative knowledge, or sometimes propositional knowledge is knowledge about properties and relations of the objects of knowledge" [p. 48]; and Operational knowledge, "also called procedural knowledge consists of rules, procedures, algorithms. etc. and serves for organization of behavior of people or animals, for control of system functioning and for performing actions" [p. 49]. In terms of my deep interest in the biology of knowledge and what is at operation in its production, how is it that we can discern properties, and store this knowledge at the ready for the understanding of a new, growing context that might need this knowledge in the mind / brain to build on? Burgin touches on this later in the book.

In section 2.1, Burgin takes on "an exposition and exploration of diverse classifications and typologies of knowledge." [p. 40] Here he provides an elaborate list of types of knowledge as drawn from differing authors.

Perhaps one of the most salient classifications has to do with the Existential characteristics of knowledge, Burgin presents a quote from Jacob Bronowski to bring in the section "Knowledge Is an Unending Adventure at the Edge of Uncertainty" [p. 77]. He goes on to state:

> Thus, discussing existence of knowledge, we need to explain what knowledge is and here we come to a big problem. From ancient times…philosophers and other researchers have tried to build a comprehensive definition of knowledge and still different opinions exist causing a lot of controversy in the area. There were many suggestions but in spite of this, the diversity of essences called knowledge evades any exact and comprehensive definition. [p. 77]

Burgin states "in a similar way, Fayyad et al. (1996) write 'knowledge…is purely user oriented and domain specific and is determined by what-ever functions and thresholds the user chooses" [p. 81]. He notes "An interesting approach to knowledge posits it as a process of knowing. For instance, Polanyi (1974) regards knowledge as both static 'knowledge structure' or 'knowledge item' and dynamic 'knowing'" [p. 83–84]. This points to both knowledge production of human biological processes and knowledge as an abstraction of human processes into to artifacts like books, as well as operative, process-based languages like the vast varieties of computer code.

Related to my above comment, I am quite interested in how we define and store these categories in terms of our own human biological systems. As I understand it, we cannot fully entail how this process becomes operative at this time, biologically. This is to say that we are still at the limits of technology to articulate operative brain/mind structures. How can we develop new knowledge and new technology to do this?

As we begin to parse and discuss relationships between differing computational approaches and the precision of model development, it is important to note that "significance of knowledge is a relative characteristic, which depends on the person or system that evaluates that knowledge" [p. 131]. Operational knowledge is central to computational processes, and the gaining of new knowledge in the development of new operational processes as learned from the failure and successes of existing processes is central. Yet, how is this success or failure decided? Perhaps, we should mention the role of the programmer in the creation of such systems in terms of the breadth and depth of potential operational material that is later brought under scrutiny by the evaluator (which may be the same person?). My question here is, in terms of movements like Black Lives Matter, how can we better write programs to reflect diversity populations especially in terms of AI and data mining? How can we somehow transcend personal biases when using operational algorithmic processes for knowledge production? Perhaps this suggests that high-level code, especially AI code might need to be written and/or scrutinized by groups of programmers that are representative of many social perspectives.

In Section 2.4, The author explores "knowledge about metaknowledge and metadata, where metaknowledge is knowledge about knowledge, while metadata provide information about data" [p. 40].

Burgin discusses metadata research:

> Metadata research emerged as a discipline crosscutting many areas and domains. It has been directed at the provision of structural descriptions (often called annotations) to Web resources or applications. Descriptions, in the form of metadata, function as a basis for advanced services in many application areas, including search and location, personalization, federation or repositories, and automated delivery of information. [p. 154]

In my own work I have explored the use of key words which often alternately function as metadata. I somewhat playfully and poetically have used these terms to build a user driven combinatoric sentence generator (drawn from multiple key word lists) that when combined and recombined occasionally point to new knowledge potentials (Seaman, Berreth, & Perriquet, 2014).

Additionally, I have explored interactive meta-meaning processes through the interaction of a user of a particular generative virtual environment. This was in part the subject of my own PhD thesis. Burgin points out:

> While logic is concerned with formal systems and proofs in these systems, which are expressed in some formal language, metalogic deals with formal systems and proofs in these systems, which are expressed in a metalanguage about some object language in general and a logic language in

> particular. To distinguish metalanguages in general to metalanguages in metalogic, we call the latter by the name metalinguistic languages. [p. 167]

Perhaps my world generator system is a poetic variety of such a system (see Seaman, 2010) a recombinant poetic metalinguistic language system. It enables the user to explore poetic meta-meaning through interaction with the formal computational system through building complex virtual worlds in real time. Although, there is no formal mathematic proof, the subjective interaction of a user enacts the operative logic that enables the building of diverse virtual worlds. Here again, this is a form of domain specific knowledge that can be drawn from the Burgin's book and applied to differing operational computational domains as associated with the individual reader's domain-specific interests. I may be wrongly attributing this reference here through a misunderstanding, yet sometimes displacement illuminates placement and leads to new knowledge production in relation to intuition, mentioned above.

Chapter 3

In chapter 3 Burgin discusses the idea that "it is necessary to not only know properties of knowledge but also be able to evaluate and justify these properties" [p. 40].

> Here we consider evaluation in a much broader context. First instead of belief evaluation of epistemic structures, which include beliefs, models, ideas, concepts, and all kinds of knowledge. Second, not only truth evaluation is studied but evaluation of other properties of knowledge such as consistency, exactness, or fuzziness. Third, evaluation is treated in the context of diverse scales in which the evaluated properties take values. This is different from truth evaluation, which traditionally takes into account only two values—True and False. [p. 169]

This is an exciting comment from an artist's perspective in terms of future poetic systems which might involve AI and other computational approaches (Seaman, Berreth, & Perriquet, 2014). Again, returning to an association related to the biology of human knowing, humans have multiple systems which contribute to thought processes. Some are somewhat discreet—like synapses (the true and false model). Yet some are more analogue in nature—like neural transmitters which operate and change the output from the discreet nodes. When the computers were initially being created the predictability of a discreet true/false system was chosen over the noise of analogue systems. Von Neumann discusses this in his complete writings (1995, pp. 534–535). Yet for me, human creativity arises from an intermingling of the clarity of the true and false as intermingled with poetic noise. How are poetic computational systems different in terms of their logic to that of other, more pragmatic systems?

Given the above, Burgin points out that we follow through with evaluation, justification and testing of these structures and spaces.

> In the context of epistemic structures in general and knowledge, in particular, evaluation means finding properties or values of properties of these structures (knowledge). In a more strict sense, knowledge evaluation also means evaluation of the epistemic structures properties related to knowledge, e.g. properties that allow discerning knowledge from other structures. [p. 170]

Because there exists a myriad of knowledge domains the question becomes how to best bring about such knowledge evaluation and updating. We must also deal with time and changes over time as well as how new knowledge can replace existing knowledge, that is, in the sciences, and so forth.

In section 3.3, Burgin talks about "how to work with knowledge that has been traditionally considered inconsistent giving an overview of existing approaches to this problem and an exposition of some parts of the theory of logical varieties" [p. 41].

We want knowledge to be clear and consistent yet there are limits to this that philosophers have been aware of for ages. Burgin provides this notion:

> As we know, consistency is an important component of knowledge correctness. However, even before the concept of consistency was elaborated, people found that their thinking and knowledge are, in some way, inconsistent. Philosophers, especially, Zeno of Elea (ca. 490-430 BCE), explicated various inconsistencies and contradictions in the understanding of natural processes. [p. 263]

This is most famously exemplified in Zeno's paradox related to the infinite nature of travel when one moves half the distance closer to the destination in each daily increment, one will never arrive. Interestingly Burgin points out that "Minsky was one of the first researchers in AI who attracted attention to the problem of inconsistent knowledge" (Minsky, 1974) [p. 263]. Minsky suggested that "there are no completely consistent AI systems. Burgin states: "Minsky (1991) suggested that consistency and effectiveness may be incompatible" [p. 263]. This certainly presents an interesting paradoxical variety of thought as it pertains to knowledge production. The fluxus artist and scientist George Brecht (1979), working with Patrick Hughes, wrote a fascinating compendium of paradoxes called *Vicious Circles and Infinity.* After reading this, one begins to understand that paradoxes exist because the world is more complex than language's ability to reflect it. Given that code is a particular variety of language, this observation becomes quite interesting as it relates to knowledge production and code languages in general.

Central to Burgin's thought concerning the future of logic are logical varieties, prevarieties and quasi-varieties:

> Logical varieties, prevarieties and quasi-varieties represent the natural development of logical calculi, being more advanced systems of logic, and thus, they show the direction in which mathematical logic will inevitably go. Including logical calculi as the simplest case, logical varieties and related systems offer several benefits in comparison with conventional logic. [p. 271]

In particular, "logical varieties, prevarieties and quasi-varieties give an exact and rigorous structure to deal with all kinds of inconsistencies" [p. 271]. The author goes on to articulate a series of these functions and their potentials. I will provide this list in an abbreviated manner here:

> Logical varieties, prevarieties and quasi-varieties … allow modeling/realization of all approaches of inconsistent knowledge; … realize non-montonic inference; … provide more efficient application of logical methods to problems in different areas; … allow partitioning of an inconsistent knowledge

> system into consistent parts without loss of information, while at the same time preserving a possibility of using powerful tools of classical logic for reasoning and justification … this enables an inconsistent logical system … and … restructures it into a logical system of logically consistent components; … allow utilization of different kinds of logics in the same knowledge system, possessing multifunctionality in applications; … allow separate parts in a knowledge system and allow working with them independently when these parts either demand different logics or satisfy dissimilar (sometimes contradictory) conditions, or employ distinct rules for transformations and/or interpretation; … provide for means to reflect changes in beliefs, knowledge and opinions without loss of previously existed, knowledge and opinions even in the case of new beliefs, knowledge and opinions contradict to what was before; … provide means for knowledge representation in multi-agent environments; … provide means for efficient and management of distributed knowledge and databases; as well as … provide means for efficient and management of temporal knowledge and databases. [p. 271–273]

This is an incredibly important set of branches of logic which are flexible in many different manners. Given paradoxes, and the numerous cases of potential inconsistencies discussed above, Burgin's articulation of logical varieties, prevarieties and quasi-varieties points the way forward to new kinds of code authorship related to knowledge production. Additionally he discusses multi-context systems (Weinzierl, 2010) [p. 274] to add to this list. The author also provides a complex diagrammatic mapping of a framework for dealing with inconsistencies. [p. 276]

In the next part of the book, Burgin separates and studies "three key levels of knowledge: the microlevel, macrolevel, and megalevel (Burgin, 1997)" [p. 41].

Chapter 4

In Chapter 4 the author describes "the microlevel, or the quantum level of knowledge, its structures, properties and processes. This level contains 'bricks' and 'blocks' of knowledge that are used for construction of other knowledge systems" [p. 41].

Here we consider the microlevel or quantum level of knowledge with three main goals:

- Construction of an adequate mathematical model of knowledge units;
- Explication of elementary knowledge units;
- Exploration and description of elementary knowledge unit integration into complex knowledge systems. [p. 307]

Burgin discusses how these units form "'quantum bricks' or 'quantum blocks' of knowledge that are used for construction of other knowledge systems" [p. 307]. He describes three main theories that employ these units:

- Quantum theory of knowledge (QTK), which studies knowledge quanta of different types;
- Semantic link theory (SLTK), which studies semantic links of different types;
- Semiotics, which studies signs and symbols as quantum units of knowledge. [p. 309]

This is a fascinating poetic mixed metaphor bridging physics with architecture. This mathematical approach employs the ability to break equations into parts and act upon particular sections in order to best create and explore new algorithms in the service of knowledge production.

He later discusses the importance of descriptive knowledge as being the most "typical category of knowledge" [p. 311], giving us the ability to discern an object's properties and articulate its domain. This relates to a long history of "attributive realism" [p. 311]. The goal is to create an "inherent descriptive quantum (IKQ)" [p. 311] of knowledge that can become operative as part of an algorithm.

> In a similar way, we find that individual quanta of representational knowledge, which depicts the knowledge object (domain) by models (images), and by operational knowledge, which represents the knowledge object (domain) by procedures, algorithms, instructions or processes, have a similar structure, which is also a second order named set constructed of two named sets and a morphism between them (Burgin, 2011). [p. 318]

Burgin goes on to define an elaborate series of semantic linking mechanisms [p. 331–339], that are intrinsic to semantic link theory (SLTK).

"Operations with and relations between knowledge quanta and other quantum knowledge units representing dynamics, and structural organization of the quantum level of knowledge are constructed and explored in Section 4.3" [p. 41]. Burgin traces a rich history of sign articulation processes which includes discussions related to Saussure, Hjelmslev, Eco, Peirce, Morris and others.

The author discusses differing aspects of an algebra of knowledge [p. 359]. He follows with an exposition of relations and operations between nodes and links. In particular he states: "An important concept in the operation of a semantic network is the inheritance of relations, which determines relations between semantic links" [p. 362]. He next elaborates on a series of different operations including binary operations with symbolic knowledge quanta [p. 386] and binary operations with semantic links. [p. 387]

He sums up this section:

> To conclude, it is necessary to remark on the one hand, binary relations, or more exactly, set-theoretical binary relations are symbolic knowledge quanta. In addition, it is possible to represent arbitrary relations as a set or list of symbolic knowledge quanta. On the other hand, symbolic knowledge quanta and their systems are very convenient objects for mathematical modeling and manipulation as they form regular structures and allow many operations. [p. 392]

Needless to say, mathematics as an operative discipline is central to the Theory of Knowledge as it is played out through a vast set of potential mental and computational processes.

Chapter 5

Chapter 5, is entitled "Knowledge Structure and Functioning: Macrolevel or Theory of Average Knowledge" [p. 395]. On the macrolevel, or the level of average knowledge, researchers study knowledge representation "used by people and artificial systems for practical purposes" [p. 41].

Burgin discusses AI:

> In the handbook of Artificial Intelligence, it is possible to find the following definition of AI (Barr and Feigenbaum, 1981): "Artificial Intelligence is the part of computer science concerned with designing intelligent computer systems, that is systems that exhibit the characteristics we associate with intelligence in human behavior—understanding language, learning, reasoning, solving problems and so on." This definition describes AI as a research area. At the same time, AI has another meaning. Many people understand AI as interactive intelligence realized by artificial means, having in mind computers as the most appropriate means for this. [p. 396]

In terms of ongoing research and furthering of AI, Burgin points out:

> The main attention was to the knowledge used by people in science and everyday life. This average knowledge constitutes the macrolevel of the knowledge universe. The most known models are relational and logical structures… Theoretical studies of these structures form the theory of average knowledge. [p. 398]

Next the author discusses the emergence of knowledge representations (KR)

> as an area of research aimed at representing knowledge in symbolic structures to facilitate inference and construction of new knowledge items from given knowledge systems. [p. 398]

> Knowledge representation uses three kinds of semantics: formal semantics, content semantics, and operational semantics. [p. 398]

Thus, the goal of AI is to design and produce intelligent machines. It is interesting to note that historically the bar representing intelligence has risen multiple times, for example, playing checkers, then playing chess, then playing go and so forth would at a certain given time be considered intelligent. AI as a field is moving incredibly fast at the moment. Central in part to AI are representations:

There are three substantial classes of knowledge representations:

- Abstract (structural) representations, such as formal logic or semantic networks
- Material representations, such as human brain or computer memory
- Mental representations, such as concepts, ideas, or mental schemas [p. 400]

He goes on to elaborate a series of tools that are used for knowledge representations and how these determine instrumental classes of knowledge representations:

- Mathematical representations,
- Logical representations,
- Scientific representations,
- Metaphoric representations,
- Linguistic representations,
- Schematic representations,
- Iconic representations,
- Symbolic representations,
- Algorithmic representations. [p. 401–402]

He also discusses perceptual classes:

> — Visual representations
> — Vocal representations
> — Tactile representations, e.g., the tactile writing system Braille. [p. 402]

In my own work as a media researcher and conceptual artist, toward the creation of a transdisciplinary database to enable research into a new form of AI—neosentience (Seaman's coinage; Seaman & Rössler, 2011)—we hope to layer in new AI approaches enabling multi-domain understanding to help fuel transdisciplinary knowledge production in a science/conceptual art project entitled *The Insight Engine* (Seaman, Berreth, & Perriquet, 2014) discussed in part above. The idea is to include many different classes of representation (drawing from the above list) as relevant.

It is interesting that one creates an AI tool to in turn create a higher-order, AI-related instantiation. Perhaps this embodies the notion that knowledge study potentially begets new knowledge.

Section 5.1 "explains utilization of languages, such as natural, mathematical, programming and scientific languages, for knowledge representation, preservation and processing" [p. 41]. Burgin points out that there are three structural classes of language:

> — Informal Languages, which include natural languages, such as English, Spanish or Chinese.
> — Semiformal languages, which include languages of mathematics, physics, biology, and other sciences
> — Formal languages, which include logical languages and programming languages. [p. 403]

In particular Burgin points to the need for the articulation of the specificity of the domain:

> To be an efficient tool for communication and discourse, as well as for informing, modeling, rejection, influence, formation, and expression of ideas, languages in general and natural languages in particular, have to reflect definite reality containing enough information about its domain. [p. 404]

Burgin also speaks to the importance structures and in particular the general theory of structures (Burgin, 2012) where he here describes five overarching types of structures:

> — Internal structures
> — Inner structures
> — External structures
> — Intermediate structures
> — Outer structures [p. 415]

The author points to the importance of defining the "difference between a (pure or abstract) structure and a system" [p. 417]. He states: "In a system, elements/parts may have other properties and relations" [p. 417]. "In a structure, elements/parts do not have other properties and relations except those that belong to the structure" [p. 417].

As an artist exploring computational works of art, I often explore systems which enable the layering of meaning through the incorporation of puns and media-oriented elements via the employment of a generative language system. Here linguistic and related media components function as operative elements in an interactive computational work of art where the interactant explores meaning construction through their interactive choices. On the surface of the interface one explores visualized and sonified language and media, while internally one explores the operative code that enables this experience. All in all this kind of artwork is a perfect example of second-order cybernetics in operation. My question is, despite the analogies and metaphors, doesn't the human always become active in the final interpretation of such structures and systems in a second-order cybernetic manner?

Section 5.2 "presents a means of logics, which are used for knowledge representation, validation, preservation and processing" [p. 41]. Burgin defines logic:

> The term *logic* as formal (mathematical) structure has two meanings. On one hand, a logic **L** consists of a logical language *L* together with a deductive system (logic calculus) and/or truth semantics. Sometimes a model-theoretic semantics (interpretation) is also included. The language corresponds to a part of a natural language like English or Spanish. The deductive system logical calculus) is developed to record, capture, and codify, the inferences of which are correct for the given language, and the truth semantics is built to reflect, capture, and codify the meanings, in the form of truth-conditions, or possible truth conditions, for at least part of the language L. It is also called a logical semantics. [pp. 428–429]

The creation of symbolic language systems has changed the world dramatically, where now computers employing such systems cross every aspect of life. As Burgin suggests, knowledge production crosses a vast series of differing domains which is ever expanding.

Section 5.3 "describes elements of the theory of abstract properties, which is a synthesis of logic and qualitative physics providing even more powerful means for knowledge representation, validation, acquisition, preservation and processing" [p. 41].

> The author discusses properties: Properties are very important. As the great Aristotle wrote, we can know about things nothing but their properties. Thus, it is natural that properties play an important role in mathematics, logic, and all sciences. However, concepts of properties in mathematics, logic, and science are basically different. [p. 501]

We can say every object has an infinite potential set of properties as it is explored from an ever increasing set of intellectual vantage points providing multiple perspectives over time in an accretive manner.

Burgin discusses deduction: "Deduction is a technique obtaining new true statements from given true statements" [p. 516]. He goes on to discuss expert systems:

> Usually rule-based systems, such as expert systems, consist of a set of rules in the form of productions, a knowledge base and an inference engine. The rules encode active domain knowledge as premise-conclusions and/or condition-action pairs. The knowledge base contains initial

> knowledge and previously deduced knowledge. The inference engine works in the context of a non-monotonic logic applying a conflict resolution strategy to deal with inconsistencies and handle cases where more than one rule is suitable for application. [p. 535]

As a media researcher, I have been working of creating an expert system to aid in knowledge production as related to CyberArchaeology. One of the biggest problems has related to the incompatible formatting of the diverse data which makes up the set of data under study. This includes historical photos, oral histories, documents from digs, lidar images, virtual models, maps, historical documents, related texts, and contemporary aerial photography. The notion is to use known instances as articulated by archaeologists as initial knowledge, search the database for data that relates to differing related historical attributes that have been articulated, and have the system infer new knowledge. Yet, deduction cannot happen if the disparate data is not formatted properly as needed to be employed by the intelligent system.

In Section 5.4 semantic networks and ontology are the main topic [p. 42]. Burgin provides this definition for a semantic network:

> Semantic network or semantic net is a knowledge representation formalism that is based on a mathematical concept called a graph and describes objects and their relationships in the form of a network consisting of nodes and (usually directed) links between nodes in the form of arcs or arrows. The nodes represent objects or concepts by their names, while links represent relations between nodes also by their types (names). [p. 518]

According to Burgin,

> state semantic networks are usually stable in the process of functioning (utilization) but can be changed by those systems that have permission to do this.
>
> - Linguistic networks which include conceptual networks and definitional networks;
> - Statement networks which include assertional networks;
> - Implicational or causal networks. [p. 521]

He provides an example of such a network—a lexical database of English called WordNet. "It provides short, general definitions of words in English and exhibits various semantic relations between these words, or more exactly, between the concepts named by these words [pp. 521–522].

He also discusses ontologies. A domain specific or simple domain ontology represents knowledge about a specific domain as part of the world. For instance, an ontology about computer software would model the meaning of such terms as program, programmer, programming language, and so forth [p. 527]. The creation of ontologies to function in the aid of intelligent computation is central to future knowledge production. I have been considering a project which would be an enormous compendium of relationalities that might also be employed in systems in the service of knowledge production. This might be generated through a crowd-sourced application.

Scripts and productions are examined in Section 5.5. "A script is a structured representation describing a stereotyped sequence of events or actions in a particular context (Schank &Abelson, 1977)" [p. 527]. Burgin continues: "Scripts have been used in natural language to organize a knowledge base in terms of the situations that the system should understand" [p. 528].

It must be noted that *understanding* has a slightly different meaning here than when we speak of human understanding. In a sense the word understanding is an analogy in this context. Given a particular system in operation, a script helps order salient aspects of a particular context. We often use metaphors and analogies to discuss computational mechanisms as they relate to human knowledge processes like: "Wait a moment, the computer is thinking."

"Frames and schemas are studied in Section 5.6 with the emphasis on the new direction in this area called mathematical schema theory." [p. 42]

> A frame is a data structure introduced by Marvin Minsky in the 1970s for knowledge representation that allows imitating the way in which people keep information in the brain and make use of it when the need arises. [p. 536]

"Minsky's frames were intended to help artificial intelligence systems recognize and utilize patterns and their specific instances (Minsky, 1974)" [p. 536]. Frames were used to build up knowledge about "typical objects or events from some class, such as cars, planes, organizations, people or triangles" [p. 536].

Again, a word like *recognize* is here functioning as an analogy in terms of operation within a mathematical system that is human-like. The author further states that: "Frames, semantic networks and scripts are kinds of the structure called schema or scheme, which were very popular in the field of knowledge representation" [p. 539].

Burgin notes that:

> Piaget characterized schemas, or schemes, as general characteristics of an action that allow the application of the same action to a different context by means of the mind's natural tendency to organize information, into related, interconnected structures—schemes. [p. 540]

It is interesting to note here that perhaps many of the attributes related to intelligence and knowledge production have been deduced through a form of mindful awareness—where the individual becomes self-conscious related to self-observation of the available parts of the mind as it is in operation.

He articulates the concept of a mental schema:

> In this context, a mental schema is an abstract structure of knowledge, a mental representation stored in memory upon which all information processing depends. It may represent knowledge at different levels, e.g. cultural truths, linguistic knowledge, or ideologies. They are mental templates that represent a person's knowledge about people, situations or objects, and which originate from prior knowledge and provide a framework for future understanding. [p. 541]

In the human, such schemas are being subtly updated in an ongoing manner, where knowledge is continuously in flux, often changing through the slow, measured acquisition of new knowledge.

The author points out that "a schema is both a store of knowledge and the description of a process for applying that knowledge" [p. 542]. Thus this knowledge might be reapplied to new contexts in an ongoing manner as a form of operational knowledge although an alternative view suggests that there is a limited set of schemas (Arbib and Liaw, 1995), enabling a form of activated working memory related to particular "regions of space time" [p. 542]. Here is where brain theory and new forms of observing related to what is at biological operation in the brain, needs further development. This points to the fact that in many ways we are still in the early days of fully understanding how the mind/brain functions because of its enormous complexity. How to best abstract that complexity into a new form of computational system is perhaps my own holy grail.

Burgin provides the following:

> The use, representation, and recall of knowledge is mediated through the activity of a network of interacting computing agents, the schema instances, which between them provide for going from a particular situation and a particular structure of goals and tasks to a suitable course of action … This activity may involve passing of messages, changes of state (including activity level), instantiation to add new schema instances to the network, and deinstantion to remove instances, Moreover, such activity may involve self-modification and self-organization. [p. 543]

Yet, there is something unique about the human's ability to understand and change context. There is also the potential to understand how to bridge and/or merge contexts in the service of creativity, employing accretive knowledge. Can we author new computational systems that can be creative in their own manner, in a sense learning about creativity through doing and sensing systems as an accretive process, studying aesthetics, and art history for example? To me, this concept is very different to that of how computers exploring the current state of AI are making art. This also means having a true meta-level understanding of context and how the understanding of that context is arising. I see this as a future goal for AI. Yet, it is interesting to note that the "first resourceful formalization of all-purpose schemas in general and mental schemas, in particular, was achieved in mathematical schema theory developed by Burgin (2005, 2006, 2010a)" [p. 557].

A first step in the creative direction mentioned above is potentially through conceptual blending. Burgin states:

> It is a process that operates below the level of consciousness and involves connecting two concepts to create new meaning. (Fauconnier and Turner, 2002; Guhe et. al., 2011). Researchers use this operation to explain abstract thought, creativity and language. For instance, Fauconnier and Turner (2002) argue that all learning and all thinking consists of blends of concepts and metaphors based on various physical experiences. [p. 590]

The question is: Can we create new forms of computational conceptual blendings, and the ongoing blending of blendings as a future AI goal, where meta-level processes also become enfolded?

On the megalevel, or the global level of knowledge, researchers consider the immense knowledge systems such as mathematics, physics, biology, advanced mathematical and physical theories. Burgin articulates this field of fields:

> Functionally, scientific theories must make predictions, interpret evidence in new ways, and impart explanations of phenomena in their domain... [p. 598] Associational relations produced by interpretations supply the raw data for theoretical development, as well as counterexamples for discarding the theory. In addition, relevant scientific theories provide explanations of phenomena in their domain. [p. 598]

This is a dynamic set of processes that are not "static representations" [p. 598] of their domains. This might potentially include reconstructions of older theories within the computational environment. "Scientific and mathematical theories represent a transition form, from macrolevel to megalevel of knowledge" [p. 601].

The author discusses linguistic forms: "A great bulk of knowledge and many think all knowledge is represented in linguistic form, that is using language, or actually, a variety of languages" [p. 612]. He goes on to say:

> Programming languages have been continuously created for controlling computers. Mathematical languages, such as the language of arithmetic with its numbers and language of geometry with its figures, have been created for mathematical cognition and accumulating its results. Creation of logical languages have been aimed at formalization of reasoning. [p. 612]

It is interesting to speculate on the future of computational languages especially as they relate to biological processes. I am deeply interested in the creation of a new biomimetic bio-algorithm that truly is founded on the abstraction of biological processes of thinking and knowing, written in the service of neosentient knowledge production (Seaman & Rössler, 2011).

Chapter 6

This section contains "an exposition of the global level of knowledge describing structure and organization of such knowledge systems" [p. 42]. Burgin provides a working definition of the megalevel or global theory of knowledge.:

> — System Structuration organizes knowledge in the form of interacting knowledge systems.
> —Typological structuration groups knowledge with respect to different types. [p. 593]

Chapter 7

Knowledge production, acquisition, engineering and application are studied in Chapter 7. Burgin explains:

> It is necessary to understand that these processes and activities utilize data and knowledge representations. e.g., texts, schemas, formulas, etc. which, we have found before, are not knowledge itself as the same knowledge can have different representations. However, working with representations, we process knowledge, which is a very important kind of structures. [p. 643]

Although I have not mentioned it before, this book is a form of meta-knowledge structure. It writes about knowledge and its underpinnings and in so doing produces new knowledge for the reader—it functions as a structure which articulates knowledge and reflection about knowledge, leading to new knowledge.

The author states: "In addition, we ascribe cognitive abilities not only to people but also to other cognitive or epistemic systems such as intelligent technical systems, e.g., computers with corresponding software, organizations, social groups, and communities" [p. 644].

Yet, again in terms of machinic cognitive abilities there is a huge difference to that of human cognition, especially in terms of introspection and the ability to discern context in terms of meta-levels of true understanding. Do computers know what they are doing as they do it, or are they following a prescribed set of operational procedures which is given a name that relates those to similar procedures that are at operation in the human?

Section 7.1 explores knowledge production and acquisition as basic cognitive processes and section 7.2 is concerned with problems of knowledge organization and engineering.

Burgin elaborates on knowledge production:

> There are many processes in which people obtain knowledge, as well as many names for these processes—cognition, knowledge production, knowledge acquisition, knowledge creation, knowledge capture, learning, knowledge reception, experience, observation, experimentation, thinking, reasoning, perception, knowledge discernment, knowledge apprehension, understanding, judgement, knowledge comprehension, knowledge grasp, insight, knowledge purchase, and knowledge discovery. There are different interpretations to the meaning of these terms. [p. 644]

It is the goal of AI in the long term to functionally reflect each of these perspectives (given they have multiple interpretations, especially related to how humans actually think and how computers analogically think).

The author points to the fact that "Creation in general and knowledge creation is particular, is an individual, often unique action" [p. 645]. This is particularly true as related to the mind-set of the human individual, and their domain(s) of interest and past study. Perhaps in terms of machinic creativity this is still generally a reflection of a programmers own mind set, although this is changing in relation to new forms of computational learning systems, and the ability of computers to begin to come to know how to reprogram themselves using modules drawn from a variety of pre-written codes that are cut, copied, and pasted to generate new code, and are thus recontextualizing code, forming new programs.

Burgin intimates: "Production in general and knowledge production in particular, is a process that consists of separate actions of creation" [p. 645]. So now we continue parsing of the definition of creation through both its human and machinic modalities, and how these modalities can potentially inform each other—this book being a practical instrument or artifact actively involved in this process.

Burgin relays this notion concerning knowledge acquisition via intelligent systems:

> Three basic stages of knowledge acquisition by cognitive (intelligent) system are
> —Information search and selection,
> —Information extraction, acquisition, and accumulation.
> —Transformation of information into knowledge. [p. 648]

One can imagine how involved I was with the above three processes, drawing quotes from this wonderful tome in the service of this review, employing in part both artistic and scientific modes of intuition in terms of my comments. It must be noted that Burgin asserts that intuition cannot be uniquely characterized [p. 670]. He goes on: "To conclude, it is necessary to remark that although psychologists, mathematicians, and scientists studied different forms of intuition, they have not achieved a sufficiently full understanding of this phenomenon" [p. 688]. This, I believe is true for artists and media researchers as well.

In section 7.1.3 Burgin considers computers and networks as cognitive tools. Burgin posits the following:

> Let us analyze the process of data transformation into knowledge. Knowledge is achieved through information retrieval, which in its turn is based on data collection, mining and analysis. [p. 689] … Knowledge is formed only inside some knowledge system. It may be the mind of a user or an automated knowledge system on a computer. [p. 690]

There is a great interest in both the production of cognitive tools and also the production of tools to help create higher-order tools in the service of knowledge production (section 7.3). Additionally, the potential of creating distributed transdisciplinary teams of programmers and researchers as a way to articulate new knowledge is one great potential enabled though connectivity.

Chapter 7 treats issues of knowledge application and management. Burgin claims that to be efficient, KM has to include the following activities:

1. Determination and identification of needs for knowledge (information).
2. Location of needs in knowledge (information).
3. Search for knowledge (information) It is necessary to understand that such a search can unsuccessful, i.e., without findings/discovery of the necessary knowledge.
4. Knowledge discovery and collection consists of finding the necessary knowledge and bringing it to the organization. According to the current terminology, knowledge discovery is a process of transformation of data mining and information
5. Knowledge creation and production
6. Knowledge reception
7. Knowledge acquisition
8. Knowledge appropriation and representation
9. Knowledge codification

10. Knowledge storing
11. Knowledge integration
12. Evaluation of knowing
13. Knowledge sharing and dissemination
14. Knowledge hiding
15. Knowledge translation
16. Knowledge maintenance
17. Knowledge application, implementation, and utilization
18. Knowledge monitoring
19. Knowledge exchange and trade
20. Knowledge revision
21. Knowledge retirement [pp. 715–717]

Each of these processes is important to uphold efficiency. And "All of these activities go on concurrently shaping different cycles" [p. 717]. Burgin expresses:

> For instance, search for knowledge may be repeated several times before the result will be obtained or the cycle of knowledge creation—knowledge appropriation— knowledge storing is performed many times through the whole process of KM. [pp. 717–718]

The broader the set of domains under scrutiny, the more elaborate that KM becomes.

Chapter 8

Relations between information and knowledge are studied in chapter 8. Burgin asserts that:

> Knowledge is intrinsically related to data and information. This association became evident with the advent of computers. However, people still struggle to achieve unambiguous understanding of relations between these concepts… For instance, 130 definitions of data, information, and knowledge formulated by 45 scholars are collected in (Zins, 2007). [p. 721]

In a similar manner, as I try to formulate version 2.0 of my Insight Engine transdisciplinary database and search engine (Seaman, Berreth, & Perriquet, 2014), I recognize that the same word in a paper by one group, might have quite a different meaning in the papers of other groups, for example, the word *field* has many different meanings for many different fields of research. This makes appropriate computational linguistic search of that word, to build intelligent bridges [conceptual blends?] related multiple domains, problematic. I imagine I will need to create a jargon definition-in-relation-to-context tool. Burgin states that:

> Based on the general theory of information (Burgin, 2010) we further develop the understanding according to which knowledge, data and information do not belong on the same plane of reality, having as a result, dissimilar functions. [p. 721]

We must depend on context to generate a deep understanding of the interpretation and function of particular words, especially in relation to differing scientific and information-centric use as well as formal definitions that are attributed to particular words as part of a particular linguistic system.

Section 8.1 presents structural aspects of knowledge-information duality exploring different opinions about the triad Data–Information–Knowledge. Here, he discusses aspects of a knowledge-information-data relationality and how it has changed over time in the 20th and 21st century (the traditional approach). Burgin presents a long discussion concerning this topic. His upshot follows:

> Data usually means a set of symbols with little or no meaning to a recipient. Information is a set of symbols that does have meaning or significance to their recipient. Knowledge is the accumulation and integration of information received and processed by a recipient. [p. 738]

He points to how in this context "information is used to designate isolated pieces of meaningful data" [p. 738]. Burgin maintains:

> that the most popular definition for information is expressed by Rochester (1996) who defines information as an organized collection of facts and data. Rochester develops this definition through building a hierarchy in which data are transformed into information into knowledge into wisdom. [p. 739]

Alternately, an interesting semiotic interpretation is articulated by Lenski (2004) who suggests that "data denote the syntactical dimension of a sign, knowledge denotes the semantic dimension of a sign, and information denotes the pragmatic dimension of a sign" [p. 740].

So, here again, we must suggest that differing approaches make sense in relation to the domain-specific contexts, historical definitions, and uses that embody those definitions.

In section 8.2 Burgin considers relations between epistemic structures and cognitive information. The study of epistemic structures is central to knowledge production. How these structures come to relate to cognitive information is essential in coming to know a situation, be it through machinic cognition or that of the human.

Dynamic aspects of knowledge, data and information interaction are the main concern of section 8.3.

I have for many years been interested in MacKay's (1969) approach to information. Burgin provides this related note from MacKay:

> Suppose we begin by asking ourselves what we mean by information. Roughly speaking, we say that we have gained information when we know something now that we didn't know before; when 'what we know' has changed. [p. 760]

This reminds me a bit of the dictum from Bateson where he discusses the difference that makes a difference. Needless to say, Burgin provides a myriad of researched perspectives in this section concerning knowledge, data and information.

In section 8.4 Burgin analyzes information as a source of knowledge. Looking at the interaction between knowledge, data, and information interaction Burgin impresses upon us that:

> Information changes epistemic structures in general and knowledge in particular. Using epistemic spaces as theoretical patterns of knowledge systems, we model information by epistemic information operators. [p. 766]

Such information operators, as they are updated with new knowledge, can provide the open, ever operative shift in knowledge as supported through accretive knowledge production systems.

As much as we have shown computational systems as having many positive qualities and potentials, they can like the humans that program them, make errors. Perhaps this represents a form of human error made palpable as abstracted into operational computational systems. As much as we are driven by and interested in interested in the many perspective approaches to knowledge production, one of those perspectives might be a potentially false one.

Chapter 9

The last chapter contains some conclusions and directions for future research. I will here present part of Burgin's conclusion to the book:

> Thus, we can see that knowledge is an extremely complex and at the same time, more than ever important phenomenon. It plays a pivotal role in the life of individuals, functioning of organizations, and the whole existence of society. It is important to understand the two-sided function of knowledge for a system that possesses knowledge. On the one hand, knowledge can be, and in many cases, is the source of change and development. On the level of an individual (the knower), good knowledge and its correct application can lead to a better life and higher achievements. On the level of organization, knowledge can enhance extension of activities, expansion into new domains, and improvement of organizational culture and practices. On the level of society, knowledge brings steady technological and economical progress, which accelerates all of the time. In essence, it is possible to envision knowledge processes as fundamental drivers of life on all levels. [p. 803]

Burgin has written and developed a well-researched book of great importance. He has defined a rich architecture of operative ideas and processes. He has produced a multi-perspective approach to knowledge production and in turn articulated his elaborate theory of knowledge, structures and processes. The book is a living document which as it is read is both the subject and object of the thoughts of the reader, who of course leave this architecture of thought architectures with new knowledge across a series of linked domains. The book is incredibly comprehensive. It is not always easy going, and different readers are directed to read it in differing ways, yet once it has been navigated, one feels as if they have entered a new plain of intellectual understanding.

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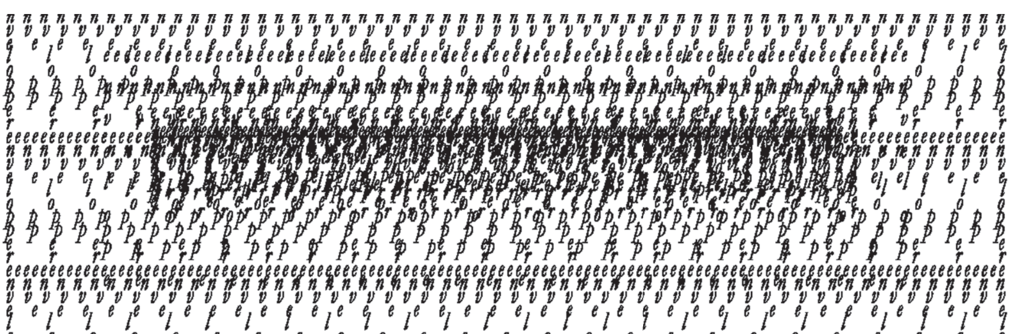

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