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On Human Intelligence

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ABSTRACT

The evolution of human intelligence is discussed as the latest of life's algorithms for constructing digital models of the nonliving cosmos. Integral parts of this process on Earth have included life's role in establishing spacetime and in devising DNA. Some effects of intelligence on animal life are described, including the introduction of consciousness. The growth of knowledge as part of human culture is summarized and some possible effects of introducing artificial intelligence are predicted.

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The Nonliving Cosmos

The nonliving cosmos contains large amounts of two materials: mass and energy. There may be other substances or objects, but we humans have not evolved a native ability to recognize them. Nonliving mass and energy interact with each other, including changing from one to the other; for example, our sun converts millions of tons of mass into energy every second. However, we humans do not discern any purpose or evolution in native cosmic interactions.

Both mass and energy exist in primary forms that we routinely distinguish. Mass occurs as solid, liquid, gaseous, or as plasma; energy as gravitation, momentum, magnetism, electricity, heat, chemical bonds, and other forms. We are also able to detect the presence of "dark" mass and energy in the Universe, which may exist in forms that we are unable to understand [1].

Life as Digitizer

Life is not an intrinsic or necessary part of the cosmos described above. Life arises in parts of the cosmos simply because it can. The main proficiency that lets life arise and flourish in the nonliving cosmos is life's ability to convert information about itself and its environment into digital form–specifically, into ordered sets of tokens. All the life that we know exists because it creates, stores, and uses digital information. No equivalent activity has been found in the nonliving cosmos.

Although non-digital forces impinge on life, living organisms have evolved digital processes to deal with them. Such processes can be devised and stored in many ways; we terrestrial humans know only how they occur here on Earth. On our planet, the forms of life today are created by evolution, defined by genetic inheritance, and maintained by physical food chains. All three processes require the coordinated creation, preservation, and use of digital information. Further details about how this occurs are the subject of Digital Reality (DR) theory [2,3,4].

Spacetime

A major part of life's digitizing its environment consists of its creation of a spacetime framework. Such a framework organizes the temporal sequences and spatial connections that our activities use throughout our lives. It provides coherence and continuity in the digitized world that life creates.

Time is not a physical object; it is a process for sequencing and linking energy and masses so they work together [5]. To our senses, time seems to be a continuous stream of events in a world filled with things. We experience spacetime wherever and whenever we cognize the cosmos we live in. What we might imagine as "empty space"–were it to exist–would be filled with compressed air, gravity, and other identifiable entities.

What we might call "eventless time"– which never exists – would be sequencing a complex process of circulating blood in our bodies, moving light and heat from place to place, etc. A living organism that somehow managed to experience true emptiness of space or lack of events in time would promptly perish.

The digital reproduction of life in a biome must follow a single track of time, so the sequence of reproduction before death is defined for all species. On Earth, a uniform timeline dominating all forms of life developed within each species' food chain. Each food chain depends on defined feeding procedures and common biochemical reactions, which take place end to end and cannot be accelerated. These food chains interact with each other to support a coherent spacetime whole. The need for time coherence has also been a problem for hardware engineers tasked to design workable computer networks, and their solutions are similar to those devised by life [6].

The Evolution of Life

Biological evolution is life's ultimate teacher. It constantly tests every organism of every species against its environment, rewarding the successful by letting them reproduce and punishing the failures by forgetting them.

Fragmentary fossil evidence appears to trace the beginning of life on Earth to volcanic activity causing temperature differences in an Archaean Sea [7]. Tiny single- celled creatures apparently lived on the free energy available near such heat gradients, but without evolution their existence would have been transient and unimportant. Life may have become a significant phenomenon when it began to produce hypothetical ribocytes capable of exchanging genetic information [8]. To speciate, life had to construct organisms that survived in various environments. To evolve, the more successful organisms had to reproduce before they died and the less successful had to die fruitless.

The process of evolution that we know–natural preservation of successful digital information in organisms that subscribe to a common timeline –may have itself evolved until it excluded other possible processes of biological evolution on Earth.

Photosynthesis and Space

It appears that early life on Earth evolved to form a limited number of species as the volcanic temperature differentials in the Archaean Sea cooled and disappeared. Various forms of selective digital reproduction may have been tried until the digital process represented by modern DNA prevailed [9]. During that time, small photo-biotic organisms apparently existed at the surface of the Archaean Sea alongside organism's dependent on volcanic heat [10].

That biota, exposed to sunlight, may have developed early photosynthesis. In this way, species dependent on unstable marine hot spots would have eventually been replaced by species able to harvest radiant heat from a dependable Sun.

The Earth and the Sun are two masses that move by gravitation and momentum in complex ways. To survive and become dominant, photosynthetic species on Earth must have evolved a digital understanding of these motions in a frame with three degrees of freedom. That frame ultimately joined life's common understanding of time to produce the four–dimensional spacetime that life and science know today. It is significant that in that frame all other physical motions and timings on Earth became understood relative to the universal vector of propagation of life–giving light [11].

As food chains based on solar energy evolved, plants containing chloroplasts dominated life on Earth. Animal-like creatures also evolved during that time, but they were constrained by the scarcity of oxygen in Earth's atmosphere. Fortunately for us, life on Earth evolved to favor plants that stored carbohydrates and released oxygen. The mitochondria that supplied animal energy were eventually able to reverse photosynthesis by oxidizing food stored in plants. A major part of life on earth shifted from phototrophic- feeding on sunlight- to organotrophic-feeding on living organisms that fed on sunlight. Predation became an important living activity as animals evolved, both learning how to eat plants and how to eat other animals.

Animal Predation

The emergence of animals from water as our planet cooled, and their distribution over the entire Earth, altered the food chain. Plants remained the primary recipients of solar energy, converting it into chemical energy. But animals evolved two feeding strategies: herbivores ate plants, while carnivores ate plants, herbivores, and each other. Plants could protect themselves from herbivores by the conformations of their species–they enclosed seeds in shells or in underground tubers, grew leaves out of reach, etc. Animals nourished and protected themselves by evolving individual skills, both predatory and defensive. One animal genus, humans, excelled all others by developing consciousness and harnessing digital information.

As we humans evolved, our cleverness and our ability to learn new skills surpassed anything previously known on Earth. The reason for this proficiency rested in our brains, which evolved to support the complex and vivid mental life that we call consciousness.

Consciousness and Science

Philosophers from Plato on have analyzed our consciousness and agreed that its most advanced feature is our skill at creating or knowing internal mental worlds. In those worlds we can imagine our participation in complex realities not actually present. This lets us rehearse situations and solve problems without disturbing the nonliving cosmos of mass and energy.

One product of human consciousness is modern science, which competed deeply with religion in the 16th century and became legitimized in the 1830s when "natural philosophers" suddenly became "scientists." Modern science was launched in England with the objectivistic goal of basing knowledge on the reasoned interpretation of "hard facts"–not on folklore or hearsay or revelations [12]. In this role, science immediately provided an epistemological basis for the Industrial Revolution. But science's early foundations lacked three elements–evolution, set theory, and information theory–that might have been included had they been known at the time. In the event, these elements (described in the next section), were discovered only after many of science's working assumptions had hardened into doctrine.

Scientific Updates

The following events occurred after the founding of modern science:In 1859 Charles Darwin explained organic evolution [13]. Science incorporated evolution as a biological process but did not recognize the effect it had on epistemology. The scientific method continued to be treated primarily as a task with innate, fixed objectives, not as a flexible research tool constantly updated by the evolution of human knowledge.In 1874 Georg Cantor introduced set theory [14].

Scientific interpretations had been based on mathematics because that was the most complete abstract discipline for analyzing data available at the time. In the 1920s set theory became an axiomatic discipline more complete than mathematics, but it was used only sparingly for scientific explanations [15].

In 1936 Alan Turing delineated the general way that digital computers worked and in 1945 John von Neumann described how a workable digital computer could be built [16,17].

In 1948 Claude Shannon launched information theory by explaining how machines using Boolean algebra could process and store knowledge digitally as sets of binary tokens [18].

In 1968 Douglas Engelbart demonstrated to a meeting of the American Association for Computing Machinery how digital computers could perform a wide range of intellectual tasks besides computation [19]. This proof of concept launched what became called "the computer revolution" and inspired the introduction of the popular Apple computer in 1976.

Computer Science

Although they may call themselves scientists, computer architects are not trying to discover scientific facts. What they are trying to do is make machines act like people. Every new software concept and every new approach in hardware design is an experiment in behavior. It is an attempt to emulate what people do. When a computer makes a correct decision or generates an intelligible output, it confirms the experiments that went into its design [20].

One feature of most computers today is that they manipulate digital information, not analog signals. Although the input information might come from a keyboard, image scanner, or modulated electric current, before it arrives at the computer's input hardware it passes through a stage of analog-to-digital (A/D) conversion.

Modern Digitization

Evolution, set theory, and information theory all define ways that life differs from the cosmos in which it lives. Evolution is a temporal process that sustains and improves life through natural selection. Set theory organizes life's basic understanding of its environment in ways that numerical or verbal analysis cannot match. Information theory helps digital data build on itself. The common thread that runs through these three foundations of life–evolution, sets, and data–is that they are all dependent on the digitization of information.

Digitization was known to the ancient Greeks and Romans as a way to simplify numerical data and store it permanently. For example, Vitruvius described a cart-like *odometer* that dropped a pebble in a box every mile it was rolled. The resulting boxed sets of stone tokens (called *calculi*) could be counted and saved as permanent records of the distances between towns.

The Romans would have been baffled by the ways that modern computers store text, pictures, and entire realities as sets of microscopic optical or magnetic tokens. In 1957 Russell Kirsch digitized a photograph into 30,976 pixels, preserved these tokens electronically, and then reconstructed from them the original image on a cathode-ray tube [21]. By the 1990s libraries around the world routinely preserved the paper images in their collections digitally, as sets of magnetic or optical tokens.

A good example of biological digitization at work is the DNA molecule. DNA stores digital data-much of its millions of years old–as sets of four amino acid tokens strung along a helical molecule. Virtually every creature capable of living contains DNA. It defines the creature's physical structure, helps its biological species adapt to its particular environment, and gives one species, *Homo sapiens*, an unprecedented ability to innovate by manipulating information. None of this would have been possible if biological data had to be stored in analog form.

Digital Data

We humans are particularly interested in the most recent benefit of digitization–our ability to manipulate data, both in ordinary behavior and in consciousness. To organize digital data in our brains we have evolved the technique of dividing it into three distinct kinds: *behavioral*, *physical*, and *ideal*. Behavioral data consists of our internal sensations and thoughts; physical data reveals a tangible, independent world of things outside us; and ideal data includes our understanding of universal patterns and truths that we feel subsist independently of the physical world and our behavior in it. Taken together, these three types of data reveal to us what we understand to be reality. They also roughly represent the *mind*, *matter*, and *forms* of ancient philosophy.

Set theory provides the mechanism by which the behavioral, physical, and ideal forms of digital reality work together. Its digital categories are more "lifelike" than the abstractions of mathematics. Philosopher John Sowa puts it this way[22]:

In modern physics, the fundamental laws of nature are expressed in continuous systems of partial differential equations. Yet the words and concepts that people use in talking and reasoning about cause and effect are expressed in discrete terms that have no direct relationship to the theories of physics. As a result, there is a sharp break between the way that physicists characterize the world and the way that people usually talk about it.

The interactions between human behavior, physical reality, and abstract thoughts can be modeled by expressing those entities as sets connected by set theory's power set axiom [23].That axiom asserts that for every set there can be a set whose elements are all its subsets. To take a simple example, if a set contains three elements-x, y, and z-its power set will contain eight elements, all of which will be sets. Thus, the power set of the set {x, y, z} will be writte{{}, {x}, {y}, {z}, {x, y}, {x, z}, {y, z}, {x, y, z}}.

This set contains all the sets that might be constructed using none, some, or all the elements in its base set, which is assumed to be already known. Call it a set of "possible sets".

In normal human understanding, physical objects are power sets of behavior and ideals are power sets of both behavioral and physical events. In simple terms, we understand physical objects by consulting our behavioral sensations when we observe them, and we understand ideals by abstracting the physical actions and visible properties of both living and nonliving things.

We can also see the sequence *behavioral* > *physical* > *ideal* in the evolution of life's species. Simple organisms feed and breed as chance and their behavior allow. More complex organisms do the same by using evolved hunting routines to pursue specific physical objectives. The most creative organisms, mainly humans, use ideals obtained from conscious power sets to develop complex intelligent techniques (such as farming and the domestication of other species) to meet their needs.

Culture and Consciousness

Like other animals, humans evolved to feed themselves with chemical energy, created either by the chloroplasts in photosynthetic plants or by mitochondria in other animals. But in a burst of creativity, humans added a complex new layer to their inanimate environment. Fire became a tool for cooking and safety, natural caves became shelters, sticks and stones became weapons, all by exploiting the contents of physical power sets.

Possessing and using these new physical things then required new social patterns inspired by behavioral power sets. Family groups became tribes that shared fires and shelters, toolmaking was passed down through generations and became a basis for trade, leaders and shamans guided everyday behavior. What we know as societies and civilizations were born.

The natural evolution of ideals in human brains'abstracted by constructing power sets of both behavioral and physical realities'required a kind of personal laboratory in which those concepts could be manipulated and perfected. This location, consciousness, had to be capable of representing the ideals in physical and behavioral power sets without overt behavioral or physical action. It also had to be accessible to multiple humans through media such as language. In practice, consciousness fulfilled these needs and more, thus becoming a major tool for grasping both cosmic events and human behavior.

Artificial Intelligence

Today a new technology–artificial intelligence (AI)–has abruptly entered human history. It mimics human life, but it is able to store and process information with speed and complexity far beyond human capabilities.

A potential use for AI will likely be the search for other forms of consciousness in the cosmos. Because our terrestrial reality has evolved to serve life on a planet that orbits its energy source, we may find it difficult to communicate with organisms that have evolved in different spacetime environments. An AI computer might be programmed to assume it was located on a different planet, thereby letting it operate in a different spacetime environment. The AI computer could then serve as a translator between us and other conscious beings.

Any computer architect will affirm that AI requires digital processing; no analog computer could emulate its capabilities. Hence, AI's success in overcoming our terrestrial spacetime limitations could also serve as a "proof of concept" for the central thesis of this paper: that human intelligence depends on constructing digital models of a nondigital cosmos.

Conclusions

To understand life and its relation to the cosmos, it is necessary to realize that the cosmos consists only of mass and energy interacting non–digitally. Life uses mass and energy taken from the cosmos to construct itself, following techniques specified by digital information that life stores within itself. Life's most basic influence on human intelligence is its division of reality into three disjoint digital sets-behavior, physical reality, and ideals. These sets, connected to one another by the power set axiom of set theory, contain digital information that represents what we know when we believe we know reality. Additional digital constructions made by life on Earth are time, which supports evolution, and space, which supports solar energy harvesting.

Thus, our spacetime–linked to the speed of light–is part of our reality but not integral to the cosmos. A potential consequence is that an AI digital computer not restricted to human spacetime might be able to communicate with intelligent extraterrestrial organisms who have constructed other spacetime environments.

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