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Consciousness and Mathematics: A Number Theoretic Approach to Modelling Reality

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Abstract. This research analyses the fundamentals of numbers for interpreting consciousness and reality. Complementing Gödel's incompleteness theorems, we adopted number theory to explore non-referential and self-referential constructs. By examining consciousness, causation, and fundamental mathematical models of reality, we analysed stages of cognition and the emergence of self-referencing as a limitation, which brings incompleteness and undecidability to a framework. By postulating prime numbers as a non-referential fundamental basis, the study underscores their critical role in forming a complete and decidable framework for understanding consciousness and reality. We develop a framework that establishes composite numbers as secondary constructs dependent on prime numbers. Based on the foundation of prime numbers, we explored natural numbers, consisting of even and odd numbers. We analysed Goldbach conjecture and discussed the limitations of mathematical modelling based on our analysis of primes and natural numbers. Our analysis suggests that decomposing numerical systems into non-referential and self-referential components can transcend the limitations of modelling consciousness and reality. Our framework offers a profound foundation for modelling and interpreting consciousness and reality, bridging the gap between consciousness, causation, and mathematics.

1. Introduction

Numbers serve as descriptors of reality [1, 2, 3, 4]. Any perception or phenomenon can be quantified in numerical form. This quantification facilitates the development of mathematical models or frameworks for comprehending reality. This process characterises the evolution of science from observation to axioms, theorems, and models.

Physicalism assumes that everything, including the mind, can be reduced to a physical system or phenomena [5]. The brain, as a physical system that underpins cognition, can be mathematically modelled as a large neural network that has been successful in artificial intelligence (AI). The neuron, the fundamental building block of the brain, is mathematically modelled as a combination of linear and nonlinear functions to construct AI [6, 7, 8, 9, 10, 11]. While numbers encode certain information about our perception, the ability to replicate intelligence through artificial neural networks, which are governed by mathematics, validates the success of the axioms and hypotheses we formed to build mathematics through our cognition. Therefore, our cognition might be comprehensible through mathematics.

In science, nature is logically modelled through mathematics by cognition. Relativity, quantum mechanics, artificial intelligence, and many mathematical frameworks precisely modelled fundamental aspects of nature, reflecting our understanding of the behaviour of reality [12, 11]. Cognition that logically constructs mathematical models of reality is inherently complex [13]. This complexity makes it challenging to understand reality through cognition alone. This fundamental limitation is reflected in

Gödel's incompleteness theorems [14], which assert that in any formal mathematical or logical system, there will always be true statements that cannot be proven within the system itself. Gödel suggested that the inherent self-referencing nature of these logical systems makes them incomplete and undecidable [14, 15].

Idealism, in contrast to physicalism, assumes that reality is merely a perception in the mind, where the mind is primary [16]. In contrast, Kant's philosophy posits that human experience is mediated by both sensory and cognitive faculties, suggesting that the perception of reality depends on external factors and the inherent capacities of these faculties [4]. According to Kant, this leads to a division of reality into two realms: the world as it exists independently of the perception (the noumenal world) and the world as it appears through experience (the phenomenal world). There is no direct access to the noumenal world unless interacting with and understanding the phenomenal world, which is shaped by the sensory and mental apparatus. This distinction underscores the subjective nature of human experience and knowledge, as the understanding is confined to faculties that can process and present the experience[17].

Unlike physicalism, which reduces all phenomena to physical processes, and idealism, which assumes everything is mental perception [18], *Theravāda* Buddhist philosophy recognising both the mind (*nāmarealm*) and physical reality (*rūparealm*) as true realities [19]. Further, *Theravāda* Buddhist philosophy diverges from *Kantian* philosophy [4, 17] by rejecting the *noumenon*, proposing that consciousness can comprehend the whole spectrum of reality through conscious awareness in the mind, suggesting a more coherent connection between consciousness and all forms of realities including causation. This nature of consciousness has also been suggested in contemporary research [20, 19, 21].

Our understanding of numbers, sets, and other mathematical constructs is shaped by metaphorical mappings and cognitive frameworks, making mathematics a reflection of human cognition. It serves as a tool to organise and interpret the complexities of reality, with consciousness playing a pivotal role in shaping mathematical thought [22]. The challenges of comprehending reality through cognition are mirrored in the way we engage with mathematical concepts. For example, Russell's paradox [23], which questions whether a set can contain itself, highlights the foundational challenges and paradoxes within set theory. Similarly, Gödel's incompleteness theorems [14] demonstrate that no consistent system can validate its own consistency. To fully grasp the complexity of mathematics, it is essential to focus on its fundamental attributes, which are inherently connected to awareness and consciousness.

Contemporary research modelled consciousness as an inherently chaotic process [24, 25, 20]. They proposed consciousness can be in two states: (1) self-referential (conscious of secondary constructs) and (2) non-self-referential (conscious of fundamental causation) [21]. They further state that causation establishes the non-referential state of consciousness, transcending Gödel's incompleteness theorems, making our awareness of reality complete and decidable.

Prime numbers are often regarded as the *building blocks* of arithmetic due to their apparent randomness and deep-seated connections to physical systems [26, 27]. The Riemann Hypothesis [28, 29, 30], one of the most significant unsolved problems in mathematics, posits that the nontrivial zeros of the Riemann zeta function are linked to the distribution of prime numbers. This structure appears chaotic yet holds profound order. Recent studies have explored how primes may underlie quantum mechanics and statistical mechanics, particularly energy levels in chaotic quantum systems, suggesting a non-trivial link between primes and physical reality [31]. Prime numbers are also studied with fractals and self-similarity in nature [32], where their distribution has the potential to model complex systems that blend chaotic and ordered patterns perceived in conscious experiences [33, 34].

In this research, we will analyse number theory based on primes for interpreting causation and the secondary constructs of reality. Furthermore, we will examine the limitations of computational modelling and transcend self-referencing to gain a deeper understanding of consciousness and causation.

2. Methodology

To understand reality through mathematics and logic, we must first recognise the deep connection between numbers and the essence of existence. Numbers are not merely abstract symbols; they reflect

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how we perceive and interpret the world. Contemporary research suggests the existence of two distinct causal realms, the physical world and the individual mind, which interact to form a mental construct we perceive as reality [19, 21]. Within this construct, awareness exists in two forms: 1) complete and decidable and 2) incomplete and undecidable [21]. Complete awareness focuses on causality and is free from self-reference, while incomplete awareness is shaped by illusion, bias, and self-reference. We aim to model these dual states of consciousness through number theory.

At the foundation of numerical representation, we begin with the concept of a *null* value, symbolising an undefined or unassigned state. This reflects the nature of reality in quantum systems, where states remain superimposed and undefined until an observation occurs. When observation takes place, awareness introduces a binary system of numbers grounded in the distinction between zeros and ones. These binary values correspond to the fundamental concepts of true and false or existence and non-existence.

Unlike the *null* state, where no identity is present, both zero and one in the binary system imply a sense of identity or self. This leads to the limitations of understanding, as seen in Gödel's incompleteness theorems, which highlight the challenges of self-referencing within a system. As awareness evolves through the binary framework, it facilitates deeper levels of analysis. These analyses lead to developing concepts such as classification, clustering, and regression. Consequently, perceptions, logic, mathematics, knowledge, and language emerge, evolving from the basic binary number system to increasingly complex systems.

To explore the nature of reality, we propose breaking down the numerical system into two key components: a non-referential fundamental system and a self-referential construct (see Figure 1). The *prime* number system, being indivisible, serves as the basis for establishing a non-referential fundamental system. Without computational or analytical processes, reality exists in a causal, deterministic, yet unpredictable state. This state can be represented by prime numbers, which are unique entities independent of any reference to other numbers. In contrast, composite numbers are secondary constructs emerging from referential relationships. Any computational or analytical process produces composite numbers, which, as self-referential constructs, are derived from prime numbers. Therefore, *null*, zero, one, and prime numbers form the core of our understanding of reality. All other numerical systems—whether natural, fractional, negative, or complex—are built upon these fundamental concepts to describe the nature of existence.

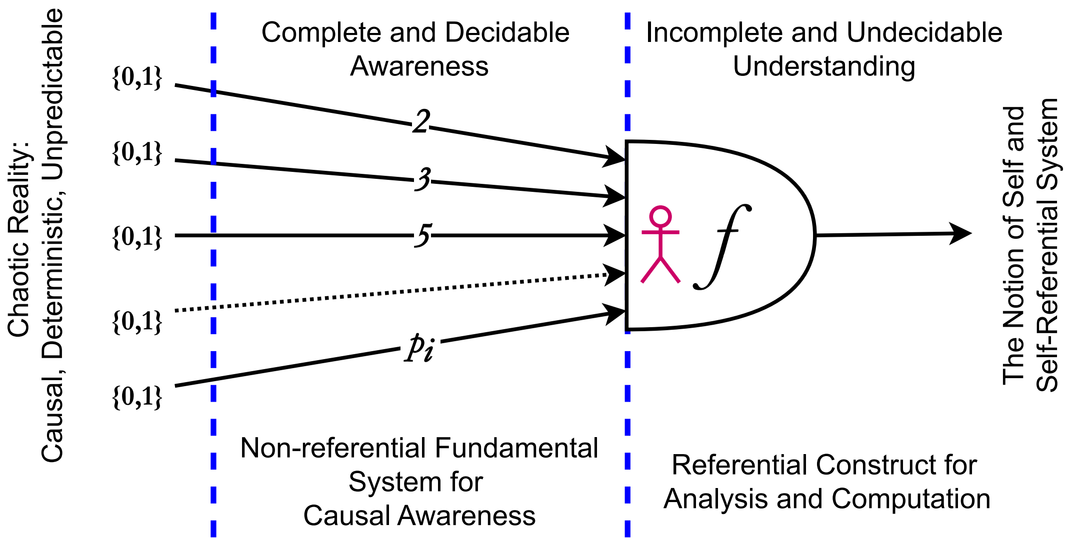

Figure 1: The illustration of reality through a numeric system based on primes. The experience of reality consists of a non-referential prime-based fundamental system and a self-referential construct.

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Let's denote the set of prime numbers as $P = \{p_1, p_2, p_3, \ldots\}$, where p_i represents the i-th prime number. We can represent this set as a vector:

$$P = \begin{bmatrix} p_1 \\ p_2 \\ p_3 \\ \vdots \end{bmatrix}.$$

By representing P as a diagonal matrix D, it is possible to construct different combinations of primes v by multiplying the diagonal matrix D by an input vector u, consisting of ones and zeros:

$$v = Du$$

where D is a diagonal matrix:

$$D = \begin{bmatrix} p_1 & 0 & 0 & \cdots \\ 0 & p_2 & 0 & \cdots \\ 0 & 0 & p_3 & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}$$

and u is a binary input vector consisting of ones and zeros, indicating which primes are used in the construction of v.

Prime number combinations, v, can be transformed using a function f to create a secondary construct for conveying various information. Different transformations lead to different perspectives, resulting in the development of various branches of mathematics, including number theory, algebra, geometry, calculus, set theory, and statistics. For example, the outcome v can be summed to construct *natural numbers* where f is the summation:

$$\sum v = \sum Du$$

This function serves as a foundation of mathematics, logic, and analytics by explaining the essential interplay between prime numbers and natural numbers in number theory.

2.1. Goldbach Conjecture

Goldbach conjecture (1742) [35], a prominent unsolved problem in number theory, asserts that every even integer greater than two can be expressed as the sum of two prime numbers. This conjecture underscores the fundamental role of prime numbers in the arithmetic structure of integers. To explore this further, consider the expression $(m+x)+(m-x)$, which simplifies to $2m$. Let m and x be positive integers such that $m > x$. Given the fundamental role of primes in number theory, let's establish that the expression $(m+x)+(m-x)$ can be symbolised as $p+q$, with p and q representing primes. This is Goldbach conjecture, which can be proven as follows:

Firstly,

(i) Let m, x, $(m-x)$, and $(m+x)$ be positive integers such that $m > x$.

(ii) Begin with the equation $a(m+x)+b(m-x) = 0$, where a and b are integers.

(iii) For the above equation to hold, a and b must both be zero.

(iv) Thus, $(m+x)$ and $(m-x)$ are shown to be linearly independent.

Then,

(v) The linear independence of $(m+x)$ and $(m-x)$ means they span a two-dimensional subspace and form a basis for it, representing its two dimensions.

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We postulate that prime numbers are the fundamental, non-referencing basis of number theory. Therefore, decomposing $2m$ into a two-dimensional subspace and forming a basis implies that there exists at least one pair of primes, p and q, from the prime basis:

$$p = (m + x) \quad \text{and} \quad q = (m - x),$$

thereby proving Goldbach conjecture.

3. Discussion

We postulate that prime numbers underpin the complex numerical system of the chaotic universe, which is causal, deterministic, and unpredictable. Since prime numbers lack self-referencing, they establish a framework for the complete and decidable understanding of reality.

Any given even quantity can be decomposed into two or more numbers. The choice of these numbers is subjective. However, Goldbach conjecture suggests that there exist two prime numbers which are fundamental without self-referencing. According to Gödel's incompleteness theorem, such a non-self-referencing system is not subjective while being complete and decidable.

Goldbach conjecture can be extended to interpret odd numbers on a non-referential basis. Any odd number is the sum of an even number and 1. Given that 1 lacks self-referencing, as per Gödel's incompleteness theorem, it is valid to consider 1 as a fundamental, complete, and decidable state. Therefore, any odd number can be expressed as the sum of 3 non-referential numbers (i.e., two primes and 1). This suggests that fundamentally describing even quantities requires only two primes, while describing odd quantities requires two primes and 1.

In the context of the largest known prime number p_γ, let V denote the sum of the two largest primes. Note V is an even number. Symbolically, if p_γ and $p_{\gamma-1}$ represent the two largest primes, then:

$$V = p_\gamma + p_{\gamma-1}$$

By extending this principle, adding the next two largest primes, $p_{\gamma-2}$ and $p_{\gamma-3}$, to V yields a new even number:

$$W = V + p_{\gamma-2} + p_{\gamma-3}$$

This new even number W surpasses V and introduces a new prime $p_{\gamma+1}$, larger than the previously known largest prime, to satisfy Goldbach conjecture. This phenomenon demonstrates how Gödel's incompleteness and undecidability emerge in natural numbers and the expansion of prime numbers for constructing the natural numbers. Euclid proved by mathematical induction that there exist infinite prime numbers (see Appendix A).

The concept of infinite primes challenges the idea that the sum of all positive natural numbers converges to -1/12, as shown by Srinivasa Ramanujan [36] (see Appendix B) and through the regularised Riemann zeta function [37]. However, this proof does not apply to prime numbers, which are unpredictable and divergent. According to Gödel's incompleteness theorem, the secondary construct of natural numbers is neither complete nor decidable. Consequently, proofs involving natural numbers do not align with the foundational prime numbers that constitute the complete and decidable framework of reality. This discrepancy should be understood as a limitation when interpreting reality based on mathematics that is not founded on a complete and decidable basis like primes.

4. Conclusion

This research explores the role of numbers in representing reality, contrasting non-referential and self-referential mathematical systems. By analysing Gödel's incompleteness theorems, we highlighted the limitations of understanding reality with self-referential mathematics.

Prime numbers, as non-referential entities, are proposed as the foundation of mathematics that reflects the chaotic nature (i.e., causal, deterministic, and unpredictable) of reality underpinned by consciousness. Unlike composite numbers, which are derived from primes and involve self-referential cognition, primes embody causation and consciousness directly. This prime-based framework not only aligns with chaotic consciousness but also transcends self-referential constraints to offer a complete and decidable perspective on reality.

The exploration of Goldbach conjecture, which shows that any even integer greater than two can be expressed as the sum of two prime numbers, reinforces the fundamental role of primes in number theory. This insight challenges traditional numerical systems and suggests that by separating non-referential and self-referential components, self-referential limitations can be transcended in pursuing a complete and decidable understanding of reality.

Ultimately, prime numbers, as the fundamental basis of mathematics, offer a unique framework for connecting consciousness, neuroscience, physical science, and mathematics. By applying this framework, future research can inspire innovation across fields, from philosophy to science and technology, deepening our understanding of both consciousness and reality.

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Appendix A. Euclid's proof of the infinitude of primes

Euclid, one of the most prominent mathematicians of ancient Greece, provided proof that there are infinitely many prime numbers. This elegant and simple argument is considered one of the foundational results in number theory. By assuming the contrary, Euclid demonstrates that any finite list of primes can always be extended, leading to the conclusion that the number of prime numbers cannot be finite [38, 39].

Assume the contrary, that there are only finitely many prime numbers $p_1, p_2, \dots, p_n$. Now, let P be the product of all these primes, i.e., $P = p_1 \cdot p_2 \cdot \dots \cdot p_n$. Then consider the number $Q = P + 1$. Now, Q is either prime itself or it is composite.

- If Q is prime, then we have found a prime number larger than any of the primes in our finite list, which contradicts the assumption that $p_1, p_2, \dots, p_n$ were all the primes.
- If Q is composite, then it must be divisible by some prime number. However, none of our finite list of primes $p_1, p_2, \dots, p_n$ divides Q because if any of them did, it would also divide P, and therefore it would divide the difference $Q - P = 1$, which is impossible. So, Q must be divisible by some prime not in our original list.

In either case, we arrive at a contradiction. Therefore, our initial assumption that there are only finitely many primes must be false, and thus there are infinitely many prime numbers.

Appendix B. Srinivasa Ramanujan's proof of the convergence of the sum of natural numbers

Srinivasa Ramanujan, an extraordinary Indian mathematician, made significant contributions to mathematical analysis, number theory, infinite series, and continued fractions. Among his many intriguing results is his work on the sum of natural numbers. Despite the fact that the series $1 + 2 + 3 + 4 + \dots$ diverges in the traditional sense, Ramanujan provided a framework under which this sum could be assigned a finite value. His approach, which combines elements of series manipulation and

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analytical continuation, yields a surprising and counterintuitive result [36, 37].

$$
\begin{aligned}
R &= 1+2+3+4+5+6+\dots \\
T &= 1-2+3-4+5-6+\dots \\
R-T &= (1-1)+(2+2)+(3-3)+(4+4)+(5-5)+(6+6)+\dots \\
R-T &= 0+4+0+8+0+12+\dots \\
R-T &= 4+8+12+\dots \\
R-T &= 4(1+2+3+\dots) \\
R-T &= 4R \\
4R &= R-T \\
3R &= -T \\
R &= -\frac{T}{3} \\
T &= 1-2+3-4+5-6+\dots = \frac{1}{4} \\
R &= -\frac{\frac{1}{4}}{3} = -\frac{1}{12}
\end{aligned}
$$