All, One, Infinite: The Interpenetration and Opposition Between the Conceptual and Subjective Empirical Aspects of Mathematics

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Abstract. The philosophical exploration of the concepts of unity and infinity has always had a significant influence on mathematicians. Hegel posits that the achievement and realization of the infinite state of completeness within the finite realm is contingent upon the use of pure intellect and conceptual frameworks, rather than relying on perceptual intuition. Similar to Hilbert's exploration of the concept of infinity in his dissertation On the Infinite, it may be seen that the actualization of infinity is unattainable in reality. Instead, the finite can only comprehend and achieve infinity via abstract and purely conceptual reasoning, rather than through any kind of perceptual experience of the physical world. Hence, the attribute of ultimate perfection characterizes the concept of "true infinity," but any attempt to attain such perfection within limited boundaries is certain to be unsuccessful. This study delves into the exploration of the historical beginnings of the concept of infinity in the field of mathematics. The concept of absolute perfection is unattainable in the real world due to its reliance on the presence of infinite entities.

Keywords: Infinity; Mathematical Interpenetration; Empirical Epistemology.

1. Introduction

Frege was an advocate of logicism, the belief that mathematics is part of logic and can be derived from logical principles [1]. He tried to establish a rigorous foundation for mathematics so that it would not depend on intuition or experience. In order to derive purely logical mathematics, he undertook a three-step effort. The first step was the publication of Conceptual Texts, in which he created a formal language with which he established a system of first-order predicate arithmetic, thus providing a rigorous logical tool. The second step was the publication of Foundations of Arithmetic, in which he discussed basic concepts such as what a number is, what a zero is, and what a one is, and also established basic arithmetic relations. This laid the foundation for his third step - deriving mathematics from logic - and although his third step was broken by Russell's paradox, the work he did is highly praised [2]. On this side, this study wishes to discuss Frege's specific work on number systems, and in doing so cut through to his advocacy of logic-mathematics - emphasizing the distinction between subjective and objective/concepts and objects.

Because the Peano axioms are an important step in Frege's exploration of number systems, let's examine these five axioms specifically. Frege's construction of the number system is through the introduction of the concept of the successor of the natural numbers, i.e., Article 2 of Peano's Axioms [3-5]. According to this concept, every natural number has a unique successor natural number that is one greater than the original number. For example, if n is a natural number, then its successor natural number is n+1. This concept of successor is used to construct sequences of natural numbers. Further, Frege formulated the axiom of subsequence, which guaranteed him the possibility of recognizing the relationship between the sizes of the natural numbers. This axiom specifies the relation of succession of natural numbers, i.e., for every natural number n, there exists a natural number m, which is the successor of n. This axiom is used in the construction of the sequence of natural numbers. Again, in order to ensure the infinity of the natural numbers by means of this axiom, he introduced the fifth of Peano's axioms - that mathematical induction is conceptually justified by the existence of the natural numbers, or that it is recognized as a meta-language in the construction of first-order logic, and that from this derivation it follows that the natural numbers extend indefinitely [6].

Frege's judgment of the magnitude of numbers is based on his notion of logical rules and successors and is intended to reflect a stripping away of intuition and experience. At the same time, he makes a strict distinction between symbols and concepts, so that concepts acquire a meaning that can only be independent of the mathematical system and operate purely in the human mind. Frege uses the examples of smaller arithmetic formulas and larger numbers to refute the intuitive nature of the subject's knowledge of mathematical operations. He argues, It seems to reason that if the formula "2+3=5" is intuitively recognised, then the formula "135664+37863=173527" should also be. The question is, why not? So, where exactly do we draw the boundary between the obvious and the illogical, the huge and the small? While this is an effective and subtle refutation, this research will not think Frege really recognizes the construction of experience on this point for the phenomenal world. When think back to Descartes, it involves Hume's rejection of the law of causation, to empiricist epistemological skepticism. People find an analogous relationship to the work Frege does on this point. Perhaps we could argue with Frege that he has recognized the notion of the number formula through empirical "intuition," so how does he affirm the existence of a non-empirical epistemology? Or even, on the other hand, is not his refutation precisely an endorsement of the shaping of experience, of intuition, of habit, of our understanding? Meaning, that smaller number formulas are applied in practice more frequently than larger number formulas so that this very clear empirical recognition becomes possible. Perhaps people can understand Frege as saying that here the logician is not doubting the ability of the subject to grasp mathematical concepts (or not recognizing the fact that the part of mathematical concepts that is understood by the human being is mediated by intuition), but rather he wants to strip mathematical concepts from the subjectivity of the human mind, so that mathematics can become a singularly-existing system-i.e., an ontological structure. -i.e., an ontological structure. It was also these concepts that led to the development of what came to be known as ordinal theory - the branch of mathematics that studies the various binary relations that capture the intuitive concepts of mathematical ordering.

Through Frege, Peano's axioms, and the claims of a series of mathematicians, people are able to recognize size relations under the order relation, i.e., size relations under the general integer series. But at the same time, ordinal relations are not all size relations, this study would also like to examine size relations from a geometric perspective. The concept of number in the geometric perspective is reflected in the length of the line segment, for example, "2 < 3" in the geometric understanding of the "length of 2-line segment is shorter than the length of 3-line segment. So how are such lengths and shortnesses recognized?

Let's recall how people compare lengths. Suppose a friend and someone are going to be sharing two chocolate bars, but there is some difference in the length of the bars, how do we compare the length of the bars? They would put a section of the two chocolate bars together and compare which bar has a portion of the head coming out, and then which bar is longer. In this process, they are actually doing a one-to-one correspondence and then determining the existence. It means that they will correspond to the parts that are the same and the part that does not correspond to belong to whichever bar is longer. In fact, the method used here is much like the equivalence relation expounded in set theory, both aiming at constructing a bijection, where after mapping the intuition is able to observe the intuitive difference between the two sets of lengths - existence and non-existence.

2. Infinite Comparisons

Then succeeding, the judgment of size relations enters a very important period - Cantor's set theory for the comparison of infinite sizes [7]. First, as noted above, Cantor applies the notion of bijection to construct the notion of equivalence in the language of set theory. The set of natural numbers, the most intrinsically infinite set, was used as a unit to examine the difference between other infinite sets representing infinity relative to this intrinsic infinity. For this purpose, set theory created three concepts: base or potential, countable set, and uncountable set. A set is called countable if its base is equal to the base of the set of natural numbers (or a subset of the natural numbers) and the base of the set of natural numbers is denoted N0; an infinite set that is not a countable set is called an uncountable set. In other words, let A be a set, If |A|≤N0, then A is said to be a countable set. If |A| > N0, then A is called an uncountable set. Specifically, if we can construct a bijection between the set of natural numbers (or a subset of natural numbers) and a particular set that corresponds in meaning, or if we can construct a function such that we can use the elements of the set of natural numbers to obtain all of the elements of the set through this function, then the set is equipotential to the set of natural numbers (or a subset thereof), and then it is a countable set. For example, if the set of all even numbers consists of a set of natural numbers, we can multiply the elements in each natural number by two to get all the elements in the set of even numbers, so we are able to determine that the set of even numbers is a countable set and that it has a base equal to the set of natural numbers, which are both equal to N0. Similarly, if no such bijection or function can be constructed, then this set is uncountable, and the base of this set is greater than the base of the set of natural numbers, infinitely larger than infinity. By examining specifically, the countability and uncountability of rational and irrational numbers. People will be using counterfactuals as a method of proof in the proof process, ignoring for the moment the unprovable nor unfalsifiable nature of propositions in the ZFC system, it is necessary to prove the validity of counterfactuals and also to have to depend on the proofs of counterfactuals on the first-order logic and to consider it as a part of the meta-language. The proposition that the rational numbers are uncountable is not true, so the rational numbers are countable.

In the following paragraphs, the study examines the countability and uncountability of rational and irrational numbers:

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Examine the logical form of the contrapositive: $(p \to q) \wedge (p \to \neg q) = \neg p$ proving that this logic holds requires observing whether the truth tables are all equal.

Table 1. Logical form of the contrapositive and values

p	q	p	$\to$	q	$\wedge$	p	$\to$	$\neg$	q	$=$	$\neg$	p
T	T	T	T	T	F	T	F	F	T	T	F	T
T	F	T	F	F	F	T	T	T	F	T	F	T
F	T	F	T	T	T	F	T	F	T	T	T	F
F	F	F	T	F	T	F	T	T	F	T	T	F

The before and after truth values inside the truth table are all equal, so the proposition holds.

2.1. Rational Numbers are Countable

Proof: assume that rational numbers are uncountable. Afterwards, we come to disprove this possibility.

If the rational numbers are uncountable, even if assuming that the study can represent this mapping of the rational numbers and can make a table, then it is always possible to find some rational numbers that cannot be mapped by the set of natural numbers, and there is always an omission in the list.

Every rational number can be represented as both an approximate fraction$\frac{p}{q}$, (p,q)=1, and for all rational numbers, give it an ordering as in a list. This ordering follows a kind of zigzag (1/1, 2/1, 1/2, 1/3, 3/1, 4/1...). The list of Table 2 eliminates the same numbers as the previous ones), then 0 is placed at the top of the sequence, and the negative of every rational number in the previous list is placed after this rational number, so that the arrangement goes through every rational number, and there is not a single omission, contradicting the assumption that "there is always an omission from the list". Therefore, the proposition that the rational numbers are uncountable is not true, so the rational numbers are countable.

Table 2. The number list of rational numbers

	1	2	3	4	5	6	7	8	...
1	1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	
2	2/1	2/2	2/3	2/4	2/5	2/6	2/7	2/8	
3	3/1	3/2	3/3	3/4	3/5	3/6	3/7	3/8	
4	4/1	4/2	4/3	4/4	4/5	4/6	4/7	4/8	
5	5/1	5/2	5/3	5/4	5/5	5/6	5/7	5/8	
6	6/1	6/2	6/3	6/4	6/5	6/6	6/7	6/8	
7	7/1	7/2	7/3	7/4	7/5	7/6	7/7	7/8	
8	8/1	8/2	8/3	8/4	8/5	8/6	8/7	8/8	
...									

2.2. Irrational Numbers are Uncountable.

Proof: assume that irrational numbers are countable. After that, let's find exceptions and introduce contradictions.

If the irrational numbers are countable, it is possible to number a list for each irrational number and assume that there is not an irrational number that is not in this list. The list is shown in Table 3.

Table 3. The number list of irrational numbers

1.	$0.\overline{a_{11}a_{12}a_{13}a_{14\ldots}}$
2.	$0.\overline{b_{11}b_{12}b_{13}b_{14\ldots}}$
3.	$0.\overline{c_{11}c_{12}c_{13}c_{14\ldots}}$
4.	$0.\overline{d_{11}d_{12}d_{13}d_{14\ldots}}$
...	...

It can always be found that an irrational number makes it impossible for the irrational numbers to be covered by this list. This irrational number has a different decile than a_{11}, a different percentile than b_{12}, a different thousandth than c_{13} , and so on. So, this irrational number is different from the ones listed above, which contradicts the assumption that "there is no irrational number that is not in this list". Therefore, the proposition that irrational numbers are countable is not true, and therefore irrational numbers are uncountable. So, this irrational number is different from the ones listed above, which contradicts the assumption that "there is no irrational number that is not in this list". Therefore, the proposition that irrational numbers are countable is not true, and therefore irrational numbers are uncountable.

3. Beliefs about Functions

Next this study will focus on the role of formalization/functionalization in these two arguments for human understanding - the function speaks for us of the infinite and the whole [8].

A simple way to summarize the logical structure of the entire antithetical method is the assumption-judgment structure. Consider the above two argumentation processes, especially the construction of the list, i.e., the assumption step, in which we presuppose that we can find such a mapping form in which we can list all the elements and number them. The point to note here is that it presupposes such a notion of [all/full] - in particular, the notion of [all] in an infinite sequence - that we are able to list all the elements of an infinite set. We then proceed to analyze the fact that, in the judgment step, we want to be able to find a [state of exception] or not to find a [state of exception] as a way of determining the truth value of the proposition. This state of exception in this argument refers specifically to [non-exhaustive] relations, where we can find or not find an element that is outside the function/mapping. The short answer is to assume that we have found the notion of [full] before determining whether or not [full] actually exists here.

The obvious argument for rational numbers is to assume the notion of [full], and in turn we find that we cannot find [non-full], so that the bijection of [full] holds, and in turn because of this [full] property, this assumed bijection is correct.

For the argument for irrational numbers, then, the notion of [full] is assumed, and in turn, we find such a property as [non-full] - i.e., an element outside the assumed property of [full], so that this assumed bijection is then false.

But when people think about the question of "by what" (i.e., what differences between rational and irrational numbers lead to such two different arguments), we have to look at the other end of the spectrum - the structural differences between irrational and rational numbers that lead to differences in the way they are listed/constructed mappings - because there is nothing that can be further dissected logically in this kind of discourse. The differences in constructive mappings - to be uncovered, for there is nothing left that can be dissected further in this kind of argumentation that is logical. It is precisely because the rational numbers are an exact functional form, or that they are composed of an arrangement of the elements of different sets of natural numbers, that this form becomes conceivable in the subject's perception, and that everything we can think of necessarily belongs to this functional form, so that the [all]-property assumed here is in fact already guaranteed - -we are able to believe in a mapping of a visible function that we can imagine. It is the structure of such a visible function that preserves for us the grasp of the whole and the possibility of recognizing the infinite - there is such a function that eternally enumerates the structure of [the whole] for us. In contrast, irrational numbers are disorganized, and randomness and possibility become the only definitions of irrational numbers. The former means that for an operation such as writing out an irrational number, there is no purpose - it is best conceived as an unconscious operation; the latter expresses the consideration of the infinity of the length of an irrational number, i.e., it means that for an irrational number with a fixed length, it is not conceivable and that we are always able to add more digits between adjacent digits. Adding more digits seems to be analogous to a kind of infinite miniaturization, where we can keep adding digits. In the case of irrational numbers, then, there is no guarantee from the origin of the numbers of the structure of [all], which means that we must eternally enumerate the irrational numbers through our own efforts in order to be able to grasp [all], but in reality, we are unable to do this because we do not have a subject within the mathematical system that we can borrow - a function - to do this for our infinity. -functions that we can borrow from the mathematical system to enumerate endlessly for us.

Here people can see that man, as a cognitive subject, is infinitely close to the concept of the infinite, and as long as he lives, the closer he can get to this concept, but he will never be able to fully grasp the concept of [the totality of the infinite] because [the totality], which we will talk about later, manifests itself as a method of counting the "one," and as a being, as a finite being. And as a being, it embodies a finiteness. Then by means of functions or formalizations, one can imagine one's own way of enumerating these numbers, and so one is almost putting one's trust in the function and letting the function approach the notion of [all in the infinite] for us in the middle of it.

This subject's touch of infinite proximity to the infinite may perhaps be well understood in terms of language and propositions. Here this study would like to propose two propositions each in its own style to express this nature.

The first is "Within the flowers in the garden, there exists a flower that is red."

The second is "Either the first flower is red, or the second flower is red, or ...... (keep traversing all the flowers) is red."

Intuitively, the two propositions are more or less the same, both describing the fact that there exists a flower that is red. But if there are an infinite number of flowers in the garden, then the difference between the two propositions here becomes readily apparent. The first proposition is structurally clear: "In the infinite set S of flowers (x) in the garden, there exists a flower that is red (fx)". -- so much so that we have to use "......" to denote this proposition. It is clear that the first proposition does not work without the notion of constructing an infinite set S, and the second proposition cannot be represented at all without this "......" is not representable at all. So on the one hand the two propositions are isomorphic, but on the other hand, the first one is closer to the way a function works, where "there exists an x in S such that fx" contains all the possibilities, whereas the second proposition needs to be completely enumerated.

4. Real Infinity and Latent Infinity - The Proof of the Continuity of Space-Time for Existence

Late Wittgenstein wrote in his book Philosophical Investigations: "'Infinity' is always, in a sense, a word that lacks meaning" [9]. He suggests that we cannot just use the word "infinity" to describe a concept but must consider what it means in a particular context. Infinity is a context-independent property, and different mathematical contexts may lead us to different understandings of infinity. Wittgenstein introduces the concept of a "language game" as an intermediary between language and reality, a tool used by people in communication and thinking. He emphasized the diversity of language games, and that different contexts and purposes lead people to engage in different language games. Wittgenstein writes in his book Philosophical Investigations: "We can say that language is made up of various language games."

This statement suggests that language is not a unified, consistent system, but rather consists of a variety of different language games. Each language game has its own rules, purpose, and internal logic. People use 'language games' to communicate and can use the same words in different language games, but the meaning depends on the context. Meanwhile, Wittgenstein argued that in mathematics we use the concept of infinite sets, which is a special kind of language game. Mathematical language games have their own rules and structures which are different from everyday language games. So this explains the difference of meaning in the subject's cognitive system and in the mathematical system, infinity is a useful concept in mathematics, but it should not be considered as a description of the real world. The notion of an infinite set involves the limitations of context and language games, mathematical language games are different from weekday natural language games and the meaning obtained is different.

In philosophy and mathematics, the concept of infinity is usually divided into two types: actual infinity and potential infinity. Wittgenstein introduced this distinction in order to think more clearly about the nature of infinity.

Actual Infinities: An actual infinite refers to a set or sequence that has an infinite number of members in a given context. These actual infinities are usually used in mathematics for reasoning and proofs. For example, the set of natural numbers is an actual infinite set.

Potential Infinity: Potential infinity is a thinking tool used to describe the notion that a sequence or set can be extended indefinitely. It does not require the actual enumeration of all members but rather suggests a possibility.

It is clear from this distinction that there are two specific references to infinity. To some extent, the actual infinite tends to refer to the countable infinite, i.e. a discrete, one-dimensional, linear, functionalized one. Conversely, potential infinity refers to uncountable infinity, which is dense, two-dimensional, chaotic, and infinitely subdivided. As mentioned above, potential infinity suggests a possibility, and by extension here, this possibility is embodied in the question of the meaning of life, a sort of infinite and endless structure similar to fractals. For time and space, the extents of human thought and the spatio-temporal relations of life or existence are infinitely differentiable, that is to say without the intervention of the Planck length, the smallest unit of measurement in physics. This means that here we cannot strip each moment of itself in its entirety, even if each moment of us occupies a different spatial and temporal relation, even if each moment of us is not the same person (the material conditions and the states of thinking inherent in our bodies are different), and we cannot exhaustively line up each of our states truly in our heads, because the scale in this sense is lost and measurement becomes impossible. If one thinks that there is a minimal division of time-space, the question arises:

since each moment is absolutely different, how can one decide that the consciousness of the last us and the one of this moment is continuous? We find that the coexistence of the impossibility of ordering/distinction and the certainty of existence solves this problem very well, and since the scale becomes impossible, the counting of the "one" becomes impossible, and so the problem itself is not valid. It is this impossibility, then, that guarantees the continuity of the meaning of life and implies the certainty of the proposition "I exist".

5. Infinity in Dialectics and Infinity in Mathematics

Hegel divided infinity into two kinds, one is called "true infinity", also called "affirmative infinity" or "rational infinity", and the other is called "bad infinity", also called "negative infinity" or "intellectual infinity" [10]. The other is called "bad infinity", also known as "negative infinity" or "intellectual infinity". "According to Hegel, the "bad infinity" is characterized by the simple negation and abandonment of the finite, but the finiteness of finite things is not really negated, but repeated, and this process of infinite progress, no matter how far it is pushed back, is not a complete negation of the finiteness of finite things. This process of infinite progression is repeated, and no matter how far it is pushed, the finite remains the same, and this constant transformation never leaves the scope of finitude to reach the infinite, which is placed on the other side of the unattainable. This is not the case with "true infinity," which is not something and something else in an external relation to each other, not something outside of something else, but something in something else, i.e., in something else, i.e., in something else itself; that is to say, any given thing has something else as its own intrinsic constituent, and the transition from something to something else is not a transition to something outside of itself but to something else in itself, in something else, in something else, in something else. The transition from something to something else is not a transition to something other than itself, but a transition to something with itself, a return to something in something else. Therefore, "true infinity" is the negation of negation, the concrete unity of something and something else, of the finite and the infinite, and a whole that has no boundaries. The "true infinite" does not push the infinite beyond the finite as the "bad infinite" does but realizes the infinite within the finite. The "bad infinity" is like a never-ending straight line, while the "true infinity" is a complete circle. The "bad infinite" always has an external finite limiting itself and is not free; the "true infinite" has no external limiting itself and is the principle of freedom.

In Hegel's division between "true infinity" and "bad infinity", the source of most of the ideas is attributed to Spinoza. Spinoza distinguishes between "thinking infinities" and "imagined infinities," and the mathematical infinite series is an "imagined infinite," equivalent to what Hegel calls the "bad infinite," while Hegel calls the mathematical infinite series an "imaginary infinite", equivalent to what Hegel called the "bad infinite", whereas the "thinking infinite" is the absolutely infinite, supremely complete and unique "entity", which is not limited by anything other than this infinite. It is the only and highest free cause, and Spinoza calls this Infinite One "absolute certainty". Hegel appreciated Spinoza's division of the infinite, but Hegel thought that Spinoza's "infinite being of thought" lacked subjectivity and dynamism, i.e., spirituality. Hegel regarded his "true infinity" not only as "absolute certainty" as Spinoza did but also as a process of "negation of negation". The highest category of Hegel's philosophical system the highest category of Hegel's philosophical system, "Absolute Spirit", is the largest and highest "True Infinity", which consists of a series of subject-object oppositions from the lower to the higher, both large and small. At the same time, the opposition between subject and object is the limitation of each other, and the unity of the two is the "true infinity" that is achieved after the limitation is abandoned. The initial "true infinity" manifests itself as a one-sided finite being during the further self-development of the "absolute spirit," and thus must overcome its own finiteness in order to achieve a higher level of subject-object unity, which is also the higher level of the "true infinity. "true infinity," which rises step by step to the final and highest subject-object unity, which is the final and highest "true infinity," in which the In this "true infinity", the subject reaches the absolute subjectivity that completely overcomes the limitation of the object through a long process of limitation and overcoming limitation, i.e., the "absolute spirit", so Hegel calls the "absolute spirit", which is the supreme and final unity of subject and object, the "absolute subject" and the "absolute subject". "Absolute subject" is absolute infinity, i.e., the highest freedom.

6. Conclusion

The "true infinity" advocated by Hegel has two characteristics: first, the "true infinity" is accomplished within the framework of the thinking of subject-object relationship, and the process of the development of the "true infinity" is the process of unification of the subject-object relationship, which is the highest "true infinity". The first is that "true infinity" is accomplished within the framework of the subject-object relationship, and the process of development of "true infinity" is the process of the unity of subject and object. Secondly, Hegel, on the one hand, says that the infinity or completeness of the "true infinity" is not on the other side of finitude but can be attained and realized within the finite, and on the other hand, he thinks that the way to realize and attain the infinity of completeness in the finite is through pure thought and concepts, not through perceptual intuition. In other words, the finite realizes and attains infinity only in abstract pure thought, pure concepts, and not in something like perceptual intuition of reality, much like the impossibility of infinity in reality that Hilbert mentions in his own treatise On the Infinite. Therefore, an important characteristic of "true infinity" is absolute perfection, and this so-called perfection that can be realized in the finite is obviously unrealistic. There is no such thing as absolute perfection in the reality of finite things, and absolute perfection can only exist in abstract concepts.

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