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# On the Bayesian Geometric Model: Decision Making Using Multiple (>2) States

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# On the Bayesian Geometric Model: Decision Making Using Multiple (>2) States

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**Abstract:** We find at least 4 quantum properties that are indeed universal in some number systems; and we can use them for quantum computing and to enable quantum consciousness. Using the sets B={0,1}, N, Z, Q, and Q*, one has +4 quantum properties that one can trust, as archetypes of easy communication to friends and foes, to ignoranti or cognoscenti, and for quantum computing. This paper proposes the use of Bayesian geometry to reduce the space of possible results, reducing or increasing initial beliefs by successive experimentation. This is exemplified in biology and mathematics, and can be applied to physics and other sciences. The conclusion is that an experimental fact can be absolutely verified.

**Keywords:** quantum computing; communication; quantum logic; law of the excluded middle; laser; wave-particle duality; bayes; non-boolean; decision making

## 1. Introduction

*"When you change the solution space, you change the way you look at things, then the things you look at change." Proverb.*

When making binary decisions, one is helped by the LEM: Law of the Excluded Middle. This is fast, however, recognized as an internal measure of success, much like a Procrustean Bed. In the routine evaluation of going or not to the beach, a Boolean decision that can benefit from the LEM (Law of the Excluded Middle) favoring fast decision, one has to face an estimate of many non-Boolean variables. Weather, food availability, schedule, proximity, trip considerations, neighborhood, access, and other factors routinely play an important role, and may be difficult to estimate, oscillate, and have differing subjectIve interpretations. The solution has been to enlarge the system under consideration, but no system seems to be ever complete enough, and this can only lead to a probabilistic model.

Instead, to reduce the well-known irreproducibility in medical and other results, multiple "wormholes" to hard sciences are used at the same time with a non-boolean effective model, without infinitesimals. This connects different scientific fields with one another, in an internet, i.e., in an open network of connections of multiple open networks, using the set Q, resembling a hologram.

A similar situation is observed in mathematics, physics, and any natural science. In biology, e.g., in melanocytic lesions, one is continually faced with the decision as to whether a lesion is benign or malignant [1,2].

Also, whether to eat or not to eat meat seems like an optional decision, under a Boolean rule. However, anatomy (a discipline of natural science, thus a so-called "hard science") says [3] that all humans have 10 signature points of vegetarian eating, including long intestines, and none of carnivorous eating.

This leads to a 99.99% probability in simple uniform statistics [3] that humans are indeed naturally vegetarians. A very small (0.01\%) variance may not exist to accommodate any error, but may conform to the fact, e.g., that humans can occasionally eat meat and drink disinfectants (such as alcohol, in wine or hard liquor) or take so-called ``recreational" drugs, notwithstanding the

inescapable deleterious effects due to certain human physiological characteristics , such as intestine lining, diverticulitis[1], colon[2], and long intestine length.

They are all examples of a Boolean decision, with only two states possible: such as go or not go, benign or malignant.

However, in approaching this problem, one has to apply a number of criteria for this interpretation, since no single criterion seems to be sufficient [1-4]. To aid us, we find at least 4 quantum properties that are always present in the number systems of sets B={0,1}, N, Z, Q, and Q* [5] --; and we can use them for quantum consciousness. This is explored somewhere else, but the first three quantum properties are discussed in [5], while the fourth quantum property of numbers can be seen in prime numbers, as *indistinguishability*.

Indistinguishability sets in because one cannot distinguish any number in the prime number 163283381, it is a "blob" and cannot be split in any way. This is valid, using the set N, here on Earth and in the star Betelgeuse. It is a universal quantum property, and the fourth.

This work deals also with this problem, without taking a probabilistic approach, or proposing immeasurable infinitesimals. This leads one to deprecate the well-known Gödel's uncertainties, and solve the liar's paradox.

## 2. Confounding Factors

At present, there is no universal consensus [1-4] as to which criteria should be included in the understanding of cancerous lesions, or the relative importance or relative weight of each criterion. It is certain that this latter exercise should take into consideration clinical information, organizational, cytological, and cell proliferation-related properties of the individual lesion. It must be emphasized that there are exceptions to each criterion, and the failure to consider this may result in both over- and underdiagnosis of melanoma.

These are called, generically, confounding factors. A decision, seems certainly, is not absolute. Trying to be absolutely sure is denied by a confounding result.

How to cope with the presence of certain errors? In particular, it seems impossible to be able to cope with errors that are unknown, of unknown origin. Microbes were ignored for a long time, and only the invention of the microscope revealed the unknown origin of illnesses that seemed internal, which changed hygiene practices. Currently, the COVID virus is known to mutate apparently randomly, although one can suspect a stimulated cause. Nothing happens without cause.

Medicine, mathematics, and physics have dealt with this question, without success. In mathematics, it is known under the various aspects of Gödel's uncertainty. In physics, no one seems not willing to abandon false methods, as in classical physics and in the Maxwell equations of electromagnetism, for fearing that future results may need them, as well-known to be said by Feynman, although "wrong" results are obtained frequently -- e.g., as well-known, time is not absolute, and the laser, diamagnetism, the photoelectric effect, and photons exist and yet are not described using the well-known Maxwell equations, or wave propagation.

The decision model can now benefit from a geometric proposal using the Bayesian rule, instead of postulating a conundrum such as a wave-particle reality that cannot be measured, and is well-known to not explain simple phenomena.

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[1]A clinical condition in which multiple sac-like protrusions (diverticula) develop along the gastrointestinal tract, and can become inflamed. Physicians have indications that the main cause of diverticulitis (i.e., inflammation) is a low-fiber diet -- but eating meat has to be considered in a Bayesian model. Most people with diverticulosis don't have symptoms. Sometimes it causes pain, cramps, bloating or constipation, or even death.

[2] Eating bacon and sausages, e.g., is a well-known cause for colon cancer, a pathology. Eating vegetables is viewed [3] as the correct diet for humans and a cure for many cancers including colon cancer.

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**3. The Bayesian Rule**

By applying this model, not the frequentist model of probability, the set of possible outcomes can be depicted geometrically, and reduced by performing a successive set of independent measurements. This leads to updating beliefs rationally, to reach such a small chance of error that a reliable diagnosis can be made, for the benefit of treatment, or a reliable conclusion reached in physics -- for Boolean and non-Boolean elements, and without using an internal measure of success, with no external value.

The initially vague descriptive terms such as atypical nevus, dysplastic nevus with architectural disorder and moderate to severe cytologic atypia, can be reduced in uncertainty and indecision by the pathologist [4].

The decision whether the melanocytic proliferation lesion is benign or malignant, a Boolean decision, is then made based on several logic states, not just two [1-2], in a binary mode that mandates the LEM (Law of the Excluded Middle) as an internal measure of success, but with no external value.

**4. The Bayes Geometry**

Although humans are too biased to be absolute, how to try to let something not be left out, e.g, in order to attend particular interests? Equanimity seems hard to achieve, as one faces the liar's paradox and the unknown that is itself *unknown*. Fear has been the result, and tends to even "justify" bias, as linking intelligence with skin color.

This work suggests that one can update beliefs systematically by building a very large number of disjoint cases, large enough to (a) increase confidence in a geometric approach, and (b) create multiple connections exemplifying a Holographic Principle.

In that, one is not using probability theory as a frequentist, but in the geometry of the Bayes rule. Here, one is using a geometric view of updating beliefs.

This can be seen in [5], and is emphasized in [6].

**5. More than Binary States: Why**

This method uses a high number of disjoint states to obtain a decision on only two possible states, which is experimentally used, and not only in biology, and can even be used with computers to reach mathematics in experimental results [8].

The Bayesian rule is theoretically well-known to help reduce the probability state of the final decision, by updating beliefs, although not usually seen in a geometric interpretation -- as done here, and explored in [6].

Discussing whether R=Q or not [8], we are using 2^16, or even 3^16, disjoint states to arrive at the final decision on 2 disjoint states: R=Q or not R=Q.

Since the 2 states are mutually exclusive, there is no "gray area" in-between. By considering 3^16 mutually exclusive states, we reduce the possible space for confounding factors, and strengthen confidence in the result based on purely geometric considerations.

Instead of relying on any single evidence as proof, the Bayesian rule offers a further benefit: it enlarges the number and type of the areas of the applications, usually an independent sign of the importance of the final result to science, but also a factor to increase the credibility of the change, fighting bias, and improving early use. Bias hampers adoption of new facts, and collective evolution.

**6. Computers**

The calculations of digital computers are correct without any reasonable doubt, although analog computers can be faster.

The well-known Curry-Howard relationship defines structural logic -- that quantum information is discrete, and Gödel's uncertainty (stated before the Curry-Howard relationship) is denied logically. Thanks to Haskell Curry and William Alvin Howard.

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These are some of the conclusions of this simple statistics model, which can be used to better illustrate the power of collective 16 positive results as found in [7], when considering R=Q [8], including calculus and quantum computing using rational numbers (the set Q, not the set R).

Consider 3 states for each result n, n=1 to 16, where each result can be [8]:

(1) R is equal to Q;

(2) R is not equal to Q; or

(3) something else (both (1) and (2) is a valid logical state).

The case (3) can be considered a negation of (1), as a subcase of the state (2), and thus any result can have only 2 possible states, (1) or (2).

Then, since all 16 cases are considered true for R=Q [8], we have the collective probability of R=Q due to 2^16 possible choices for (1) and none for (2). In a decimal counting base, any space for choice (2) is then at most 1 case in 10 million cases.

With 3^16 possible choices for (1), the probability of successfully betting on any choice not being (1) decreases to at most 1 case in 10 billion cases. This is the experimental end of contrarianism, against such high odds.

Is $\pi$ rational? A stunning solution of the mystery of $\pi$ was discovered by Indian mathematicians about 1500 CE and is being rediscovered by quantum computing [5].

The number $\pi$ can be represented by the infinite, but amazingly simple, series:

$\pi/4 = 1 - 1/3 + 1/5 - 1/7 + \cdots$.

Since the set Q is closed under addition/subtraction the result of the series must be rational, hence $\pi$ is a rational number.

The same applies to e, $\sqrt{2}$, $\sqrt{n}$ when n is in the set Q, and other expressions (finite or infinite) using elements of the sets B={0,1}, N, Z, Q, and Q*, as quantum computing can calculate.

What could not be calculable is now reachable, and the well-known Hurwitz Theorem can be extended to cover all such cases.

A confusion may be caused by the familiar argument that "in a way not dependent on infinite sums at all the assumption that sqrt(2) is rational leads to a simple contradiction. There is no fraction a/b with integers a and b that is equal to sqrt(2)".

But that argument does not allow for continued fractions, which are allowed in the new set Q*. Continued fractions are not included in elements of the sets B={0,1}, N, Z, or Q, only calculable. Any square-root can be written as a continued fraction of integers.

The simple continued fraction for $\pi$ is well-known to be given by [3; 7, 15, 1, 292, 1, 1, 1, 2, 1, 3, 1, 14, 2, 1, 1, 2, 2, 2, 2, ...] (OEIS A001203).

**7. Bits and Qubits**

Let's consider the case of information, measured today by a Boolen variable, using Shannon information theory -- the bit.

If the bit were binary, it could only be manipulated like in the Shannon metaphor, by a relay -- represented by a switch, a transistor, a digital circuit. Then, information would behave as a neutral fluid, and one could only block it or let it pass.

But, since 2000, network encoding has become well-known. This allows MITM attacks, albeit also provides enhanced cybersecurity. Also, the Internet has shown that a connection involving 3 points may be faster than using 2 points, which disobeys the triangle-inequality.

These facts do not fit the relay model used by Shannon -- so, this is not a binary behavior, it doesn't fit Boolean logic. Thus, information theory needs an overhaul. The bit is not enough as a structure.

Another example is the qubit. From the information binary model, now proved wrong, a qubit is assumed to only 1 or not 1 -- a binary model in quantum computing to represent a photon.

But a photon needs at least 3 states, as found in 1917 by Einstein. The 3rd state is necessarily coherent, and allows stimulated emission-- the basis for the existence of the laser. Thus, quantum computing needs an overhaul. The qubit is also not enough as a structure.

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Updating these two beliefs (bit and qubit) are essential also to mathematics, deprecating infinitesimals and allowing the differentiation of discontinuous functions [5]. This impacts physics and other sciences too.

Science is creative destruction, as more theories are now passé -- irrevocably out of date. See [5].

## 7. Discussion

Albeit the bias of humans, some conclusions can be absolute, such as the law of gravity.

No matter what formulation is chosen for gravity, from Newton, Copernico, Einstein, or from none of these, as the ancient Mayans are well-known to have done (i.e., using integers, with no physical model of cosmic objects), astronomical calendars can be exactly calculated into millenia in the future or the past.

So, the cornerstone has been rightly discarded, serendipitously after all, until needed to complete the structure. It could not be used before any other.

The lesson is that such necessity (structural) is the mother of invention. In German, one says: “Aus der Not, eine Tugend machen”.

We now need to move forward, and it is no longer a choice -- we need to complete the structure, to evolve

The parts need to meet, it is the Holographic Principle upon our time.

Mathematics can meet physics. Infinitesimals are not needed, there is no contradiction.

## 6. Mathematical Conclusion

We arrived then at the conclusion cited in [7], that any mathematical choice against R=Q has an extremely low chance to succeed, which confirms it [5] . This is not a probabilistic result, but based on the Bayes geometry. Infinitesimals are denied based on 3^16 factors, geometrically.

This work proposes the use of the Bayes rule in a geometric interpretation of areas, to reduce the space of possible results, updating initial beliefs by successive experimentation, reaching an extremely small area of error (e.g., 1 in 3^16 parts).

Although humans are perhaps too biased to be absolute, one can now try to not let something be left out, e.g, to attend particular interests.

This work proposes an "absolute equanimity", objectively valid for friend and foe, created by a large number (e.g., 3^16) of disjoint cases, covering the entire area of possible and even impossible results. A negative can be disproven by considering the absence of its use in all cases[3].

This promises to deal with the problem of the unknown, where one cannot represent what is unknown to be *unknown*.

Furthermore, since this is not a probabilistic method, one can hopefully deal with non-probabilistic elements, such as non-ergodic and those with a quantum or changing nature, as found in neutrino oscillations, representing evolutionary, unforeseen, or unmeasurable phenomena.

Both factors represent a solution to the well-known class of Gödel uncertainties, where known true statements cannot be logically verified in a binary choice in the system under consideration, and solves the liar's paradox by reflection.

The general conclusions support that an experimental fact can be absolutely verified, and promotes the hierarchy of experiments over theory.

In addition, the simplicity of any very large number of rational number parameters beats hands down the complexity of a dozen parameters in mathematical real-numbers and mathematical complex numbers -- that are not computable or analog calculable at all.

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