



On S. J. Choi's Yum Yang Reading Method¹

Regarding Leibniz's binary system-

Sun Bok Bae²

Date of Submission: 06-09-2023

Date of Acceptance: 18-09-2023

Summary

This paper discusses the connection between S. J. Choi's *Yum Yang* reading algorithm and Leibniz's binary reading method, suggesting that they share the same intellectual origin as a result of cultural exchanges between East and West during the 17th and 18th centuries. The *Yum Yang* binary reading method, based on the 8 trigrams of the I Ching, has been a longstanding truth. Leibniz, upon encountering the I Ching in 1687, recognized its mathematical significance and further developed it. He presented the 8 Trigrams as a binary diagram to P. Grimaldi, the nominated chief of the Chinese observatory. Additionally, in 1697, Leibniz sent a *New Year's Greeting Card* to Archduke Rudolf, which depicted the creation of the universe using 16 Trigrams.

In 1703, Leibniz published an article titled *Explanation of Binary Numbers* at the Academy of Paris. During that time, he received a diagram of a round circle with 64 Hexagrams from J. Bouvet's letter. J. Bouvet, influenced by Leibniz's algorithm of the binary system, used the ●○ symbols instead of 0 and 1. In 1711, he presented *Cheonjonjibido* 天尊地卑圖 to Emperor Kangxi, which reconstructed the numbers of *Yellow River Diagram* 河圖 and *Inscription of River Luo* 洛書 using these symbols.

Simultaneously, S. J. Choi developed independently *Descent Variable of Yellow River Diagram* and *Inscription of River Luo* 河洛變數, as well as *Sun Index* 太陽之數, which decomposed the heaven-earth bridges into *Yum Yang* ●○ symbols. While J. Bouvet instructed Kangxi about the number system of the I Ching using ●○, he remained silent about the intellectual origin of the binary system.

According to G. J. Lee, J. Bouvet's origin of the ●○ symbol originated from D. W. Jung's book, *A Compendium of Calculating Method* 算法統宗. However, Kangxi expressed uncertainty about the source of J. Bouvet's research, because he could not identify Westerners. In Korea, S. J. Choi and S. G. Lee studied D. W. Jung's book and even added its title to their own copy after conducting a group study and reviewing its contents. From this perspective, it is evident that J. Bouvet and S. J. Choi shared a common understanding of the binary system using *Yum Yang* ●○ symbol. However, it should be noted that the use of *Yum Yang* ●○ symbol by D. W. Jung did not demonstrate any awareness of the binary reading method.

Leibniz's *New Year's Greeting Card*, J. Bouvet's *Cheonjonjibido*, S. J. Choi's *Descent Variable of Yellow River Diagram* and *Inscription of River Luo* and *Sun Index* are founded by *Yum Yang* ●○ symbol as 0 and 1. Leibniz's 4 arithmetic operations + - × ÷ have formally same function in Choi's addition/subtraction/division/multiplication 加減乘除 method. Leibniz suggested that reading the code of the 8 Trigrams as a logarithm of 0 and 1 would contribute to the development of information communication tools in contemporary missionary works.

S. J. Choi made significant contributions in developing *Yum Yang* reading algorithm, which correlated the movements of celestial bodies such as the sun, the moon, planets, and stars 日月星辰 with the calculations involving addition, subtraction, multiplication, and division. He supervised the renovation of I. Y. Song's

¹ This work was supported by the Ministry of Education of the Republic of Korea and the Foundation of the National Research Foundation of Korea(NRF-2020S1A5B5A17091118).

² Researcher Fellow, Institute of philosophical Investigation, Chung Ang University, E-mail:sbbaemedia@naver.com.



Armillary Clock and introduced the *Dongmunsanji* 同文算指, a Chinese mathematical text edited by Chinese missionaries, to Korea. Through these endeavors, he was able to restructure the traditional mathematics system, *The Nine Chapters on the Mathematical Art* 九章算術, into the addition/subtraction/multiplication/division system, which shared the same computational structure as Leibniz's computer that performed arithmetic operations $+ - \times \div$.

The Yum Yang reading method reveals information using binary numbers 0 and 1 represented by the Yum Yang symbols -- and —, i.e., ●○. While Leibniz was not as proficient in Chinese characters and S. J. Choi was not familiar with the binary method, both individuals. They born in the same year, independently discovered the binary reading method of I Ching with similar thoughts, akin to hyperbolas converging at a single point.

I. Introduction

The first person to introduce the ancient Chinese classics to Europe was Jesuit missionary P. Couplet, who introduced four classic books and I Ching in his work *Confucius Sinarum Philosophicus* dedicated to Louis XIV in 1687.³ Leibniz was informed of his work during his travels in southern Europe and came into contact with P. Couplet.⁴ He might come across I Ching's commentaries and illustrations of *Yum Yang*, *4 Symbolic Images* and *8 Trigrams* and *64 Hexagrams* in his publication. In Rome in the summer of 1688, he met P. Grimaldi as F. Verbiest's successor and exchanged information in the form of documents exchange on a total of 30 questions in field of Chinese science and technology. In a letter to P. Grimaldi in February 1697, he informed him that the use of the binary method will be useful for the technological means of information communication.⁵ And he showed a binary logic composition of the *8 Trigrams* as

follows.⁶

³ P. Couplet, *Confucius Sinarum Philosophicus*, 1687, Paris. 43-47.

⁴ M. Brancato (2016), 142. According to M. Brancato, Leibniz studied already the binary system in *De progressionem Dyadica* in 1679.

⁵ The binary structure of the *8 Trigrams* is actually the same as the ASCII code worldwide known today.

⁶ <https://leibniz-binary.com/ueber>.



Binary decomposition of 8 Trigrams								
Symbols of 8 Trigrams	☰	☷	☱	☲	☴	☵	☶	☳
order number of	0	1	2	3	4	5	6	7
binary number	000	001	101	011	100	101	110	111

Each Trigram is assigned numbers from 0 to 7, and its binary representation is shown next to it. This binary representation is based on the order of the natural numbers and follows a sequential pattern.

In 1698, Leibniz sent a *New Year's Greeting Card* to Archduke Rudolph. On this card, he decomposed the 16 Trigrams into binary numbers and interpreted the sequence and order of these binary numbers as a kind of image of the Christian world creation.⁷ The left side of the card shows the binary system representation for the decimal numbers 0, 1, 2, 3, 4, 5, 6, 7 (0, 1, 10, 11, 100, 101, 110, 111) written in parallel. The right side of the card shows the decimal system representation for these corresponding numbers. Additionally, the card also presents the binary system representation for the decimal numbers 8, 9, 10, 11, 12, 13, 14, 15 (1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111) written in parallel. These numbers represent a progression of the 16 Trigrams in the step of the change period from *Yum Yang*. This *New Year's Greeting Card* demonstrates the binary system and its application in representing the order and structure of the Trigrams.

The *Yum Yang* binary sequence from 1 to 16 suggests that the creation of all things can be expressed solely through the digits 0 and 1 in unit of I Ching system. This concept aligns with the Christian worldview of *creatio ex nihilo*, the idea that creation emerges from nothingness. Leibniz's intention to present the image of the universe's creation using a sequence of 16 Trigrams is likely tied to the notion that the mechanical principles of a computer can be operated using an 8-digit numerical code, and the logical foundation of a computer can be constructed using the binary

system.⁸

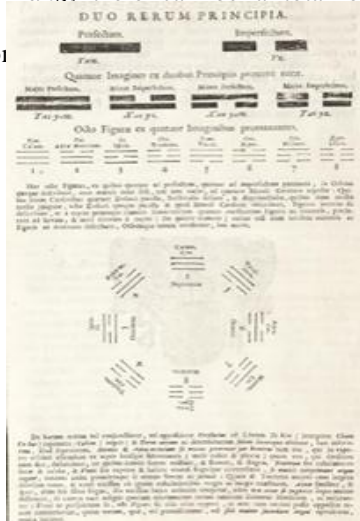
⁷ Genesis 1:1: "In the beginning God created the heavens and the earth."

⁸ The binary notation of P and Q propositions in modern propositional logic is 00, 01, 10, 11, and the combination of these four propositional values is derived by 0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111, 1000, 1001, 1010, 1011, 1100, 1101, 1110, and 1111 which are the combination of 16 propositional values on P and Q. Cf. L. Wittgenstein(1969), 44-45.



P. Couplet's *Diagram of 8 Trigrams*

Considering that there are four possible combinations of true and false for verbal transformation of two images of *Yum* and *Yang*, there can be a total of 16 propositional transformation



Leibniz' *New Year's Greetings Card* of 1698



system and its connection to the creation of all things reflects his belief in the fundamental role of binary sequences and their ability to represent complex phenomena.⁹

While P. Grimaldi gave up on correspondence with Leibniz, J. Bouvet, a Jesuit missionary succeeded letter exchange with Leibniz while his staying in Paris in April 1698 under the order of Kangxi. Leibniz sent his edited *Novissima Sinica* to him through J. Verjus, a correspondent of the Society of Jesus in Paris, and J. Bouvet sent Leibniz his own work *Portrait of Emperor Kangxi*. In this way, they were continuing the comparative discourse on the Christian world image and meaning of diagrams of I Ching. Leibniz sent a letter to J. Bouvet on February 15, 1701, and J. Bouvet replied in Beijing on November 4, 1701, enclosing a wood block copy of *64 Round Square Hexagrams*. In this letter, J. Bouvet openly congratulated that his discovery of the binary method for analysis of the *8 Trigrams* of Fu Xi. He hoped that the binary method will open a new way to unlock the secret of the I Ching that was concealed in Chinese characters in the language received from God. So, J. Bouvet could alone maintain the stance of his idea of figurism that the primitive Christian truth might be transmitted to Fu Xi as a form of a hidden vision in Chinese characters.

2. J. Bouvet's *Cheonjonjibido* 天尊地卑圖

When the binary discussion on the origin of I Ching and world creation matured, Kangxi sent down the edict and called J. F. Foucquet to the *Forbidden City* 紫禁城 and let him support J. Bouvet's research from 1711 to 1716.¹⁰ Kangxi wanted J. Bouvet to reveal the symbolic principle of the I Ching with help of European mathematics. And J. Bouvet predicted that the secret of the I Ching was hidden in an encrypted form in the Christian doctrine of the Trinity. In order to dig up the secret contained in the I Ching in 1711, J. Bouvet set up the title of the *Cheonjonjibido* by citing the first phrase "*Cheonjonjibi* 天尊地卑" of the upper part in I Ching. The sentence means "The Heaven is noble and the earth is humble."¹¹ He used ●○ instead of the code of 0 and 1 and submitted *Cheonjonjibido* to Kangxi. His geometrical construction lies in a triangular pattern of binary numbers from 1 to 10, that shows clearly that the origin of number is decomposed up with ●○ to 10 in the order of ○, ●●, ○○○, etc. from the vertex to the base.

The *Cheonjonjibido* consists of 3 parts,

⁹ A. VI. N. 320. 570.

¹⁰

https://zh.wikisource.org/wiki/%E6%B8%85%E5%8F%B2%E7%A8%BF/%E5%8D%B7_506.

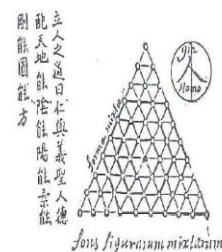
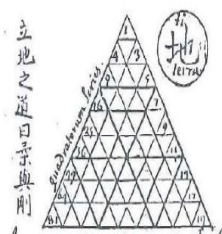
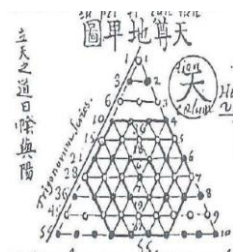
¹¹ <https://ctext.org/book-of-changes/xi-ci-shang/zh>.



heaven *Cheon* 天, earth *Ji* 地 and man *In* 人. In *Cheon*, 1 is ○, 2 is ●●, 3 is ○○○, etc., where Yum Yang is displayed with ●○ alternately from the vertex to the base of the triangle, and the odd sum is presented up to 10. The right side of the triangle in *Cheon* is written by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, and the left side is written by 1, 3, 6, 10, 15, 21, 28, 36, 45. 55 is the sum of each column. The

Cheon is a map that decompose the number of the *Yellow River Diagram* 河圖 and *Inscription of the River of Luo* 洛書 is stacked in a triangular pattern with Yum Yang ●○ symbol instead of the code of 0 and 1. So, *Cheon* was called a way of *early heaven map* 先天之圖, because it followed the number of the *Yellow River* of Fu Xi.

J. Bouvet's *Cheonjonjibido*(1711)



J. Bouvet's research results reported to Kangxi and went through a verification process specially by G. J. Lee among several scholars.¹² Although G. J. Lee said that he himself did not properly understand J. Bouvet's figure, he insisted that the arithmetic created by Westerners conforms to the logic of nature and that there is no further scattering.¹³ At that time, J. F. Gerbillon evaluated that G. J. Lee did not properly understand books of mathematics which J. Bouvet brought. But he was appointed as the *Master of the Pavilion of Liter74477ary Profundity* 文淵閣大學士 in 1712, he interpreted J. Bouvet's *Yum Yang* ●○ sequence as a variant of the multiplication method 加倍法 of Shao Yong. Kangxi presumed that J. Bouvet's triangular icon might be created by reading a letter from a westerner in the past, but he did not discuss who the westerner was anymore.¹⁴

¹² S. L. - C. Wei(2015), 122-145.

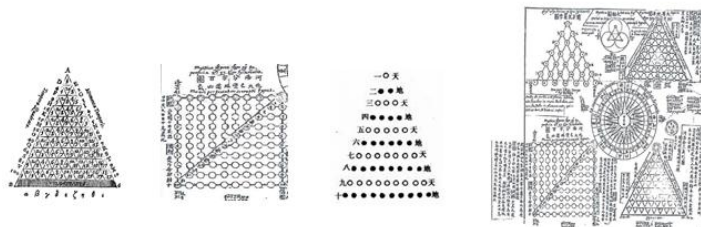
¹³ <http://ctext.org/library.pl?if=en&file=54938&page=7>. (李光地, 『榕村集』 卷二十九).

¹⁴ Emperor Kangxi said, "The icons included in this book were not originally from me, but most of them came from the old letters of Westerners. They say that there is something to be taken from the discussion of numbers here." Leibniz once said and thought that his

computer would be sent to Kangxi through J. Bouvet, and J. Bouvet is likely to have informed such a fact in the Emperor's aide as a long-time teacher of Kangxi. Judging from the fact that Leibniz showed P. Grimaldi the 8 Trigrams in binary, and they exchanged correspondence while recognizing this fact, this Westerner might be Leibniz.



Diagrams in Bouvet's *Daesangyeogsugusimdo* 大易象數鉤深圖



The *In* was taken only with \circ from the vertex 1 to 10 with 81 triangles. The *Gi* is written by odd numbers of 1, 3, 5, 7, 9, 11, 13, 15, 17 on the right side without separate $\bullet\circ$ mark and 1, 4, 9, 16, 25, 36, 64, 81 on the left side. Since the *Gi* expresses the square number of the *Luo River*, it expresses the way of Weng king 文王's posterior map 後天之圖.

J. Bouvet follows the *Earlier Heaven* 先天 in the *Yellow River Diagram* and the *Later Heaven* 後天 in *Inscription of the River Luo*, and categorizes the *Earlier Heaven* and the *Later Heaven* into three divisions: *a priori unchanging* 先天未變, *a priori change* 先天已變, and *a posterior immutability* 後天不變.

These divisions reflect the different stages and aspects of change and stability in the universe according to the *Yellow River Diagram* and the *Inscription of the River Luo*. After drawing the sun at the top of the triangle, J. Bouvet constructs the number of the *Yellow River Diagram* on the left and the number of *Inscription of the Luo River* on the right were arranged, and this was named *Declining Conjunction Triangle* 洛合三角形圖.

He called this icon *Unchangeable after Heaven* 後天不變, because the map includes the sum of the numbers of the *Yellow River Diagram* and *Inscription of the Luo River*. And he arranged the square numbers of the *Yellow River Diagram* diagonally from the upper right to the lower left of the square form from 1, 4, 9, 18, 25, 36, 49, 64, 81, 100, it is $1^2, 2^2, 3^2, 4^2, 5^2, 6^2, 7^2, 8^2, 9^2, 10^2$. He called it *100 Directions of the Yellow River Diagram and Inscription of the Luo River* 河洛分方百圖, because it indicates all direction of the *Yellow River Diagram* and *Inscription of the River Luo*. It seems to be useful for visual measurement by 100 divisions of one day.

In addition, J. Bouvet integrated *Jiaxian's Gobeobchilseungbangdo* 賈憲古法七乘方圖 into a triangular pattern, writing 1, 3, 6, 10, 15, 21, 28 as a sequence with tolerances of 2, 3, 4, 5, 6 to the left. In this pattern, a sequence of 1, 3, 6, 10, 15, 21, 28 with a tolerance of 2, 3, 4, 5, 6, 7 is written on the left side, and a sequence of powers of 2 on the right side is 1, 2, 4, 8, 16, 32, 64 were written down. This icon is the *Jiaxian's Triangle* that is a table of coefficients of the binomial theorem $(a + b)^n$ with an exponential positive integer. It is the same as Pascal's triangle.

3. S. J. Choi's $\bullet\circ$ Yum Yang reading of 4 Symbolic Images

S. J. Choi was born on July 2, 1646, in Geumgok-ri, Chopyeong-myeon, Jincheon-gun, Chungcheongbuk-do in Korea. He mastered *I*

Ching already at the age of 12, and is known as a wonderful prodigy of Joseon kingdom. He passed the first official state's exam at the age of 17, and after passing the civil service exam in 1671, went to government office and was promoted to prime minister during regime of King Sukjong eight



times.²¹ From 1684 to 1690, during the renovation work of I. Y. Song's Armillary Clock, he encouraged the activities of mathematics education of the Observatory young officers. In 1708, he produced *Gonyeomangukjeondo* 坤輿萬國全圖 and presented it to King Sukjong.²² Because Joseon kingdom introduced the *Shixian calendar* 時憲曆 in 1651, and since 1708, it was urgent to develop an astronomical calendar to solve the 5¼ degree difference between the previous 100-degree legal system and the 96-degree legal system, where division of time of 96 angles must be reformed at 360 degrees in Ptolemy's circle. Therefore, his work *Gusuryak* 九數略 seems to be interpreted as a writing of a strategy for a national policy to operate a new astronomical system. According to scholars, he retired from public office in 1710 and his work might be written between 1710 and 1715. The book is oriented at the level of strategy for the transforming from traditional calendar to western calendar oriented in T. Brahe's astronomy.

He traveled 2 times to China. In his first trip in 1685, at that time F. Verbiest, P. Grimaldi, A. Thomas, and K. Stump were still active, and in the second trip in 1697, a group of science and technology experts, including J. Bouvet and P. Jartoux, who participated in the project of *The Kangxi Jesuit Maps of 1721* 皇輿全覽圖 under the leadership of Kangxi. It seems that they stayed, but there is no record of contact with them.

S. J. Choi independently structured *Yum Yang* and *4 Symbolic Images* which are to be identified with function of $+$ $-$ \div \times . He used *Yum Yang* reading method of $\bullet\circ$ without recognizing the binary algebraic function of 0 and 1. He illustrated not only the *Descent variable of the Yellow River Diagram and Inscription of the Luo River* with the same arrangement in comparing to *Cheonjonjibido*. He described also the heaven earth bridges from 1 to 16 with $\bullet\circ$ in the *Sun Index*, which can be identified with Leibniz's *New Year's Greetings Card* of 1698.

S. J. Choi developed an arithmetic method that corresponds to the *4 Symbolic Images* of *Yum Yang* according to Shao Yong who refers the sun,

the moon, planets and stars to the *4 Symbolic Images*²³ He classified the function of the addition/subtraction/multiplication/division algorithm as calculus of movement phenomena of the sun, the moon, planets and stars. He appreciated this method as his own new discovery. The reason he claimed to have done what others couldn't do lies in his idea that he learned the reading method to reduce the number of heavens and earths to the *Yum* and the *Yang*.²⁴ His method is nothing more than to express 0 and 1 by grinding ink on an ink stone, smearing the ink on the cap of a brush, and then dipping $\bullet\circ$ on the old traditional Korean paper. Nevertheless, if *Yum* and *Yang* $\square\square$ are expressed as $\bullet\circ$, *4 Symbolic Images* $\square\square\square\square$ as the movement phenomena of the sun, the moon, planets and stars, it could be represented by the subtractive multiplication algorithm of $\bullet\circ$.²⁵ The phenomenal movement of the sun, the moon, planets and stars is symbolically at work of $+$ $-$ \times \div four arithmetic operations of adding, subtracting, multiplying and dividing with *4 Symbolic Images*, i.e. *the Old Sun* 老陽 \square , *the Young Moon* 少陰 \square , *the Young Sun* 少陽 \square , and *the Old Moon* 老陰 \square .²⁶

²³ <https://www.eee-learning.com/book/5128>.

²⁴ S. J. Choi, *Gusurak*, 今發四象新義以解九章諸法觀者毋謂創說而忽諸.

²⁵ Shao Yong says, 太陽爲日 太陰爲月 少陽爲星 少陰爲辰 日月星辰 交而 天文體盡之矣, S. J. Choi explains more concretely about the arithmetic meanings of *4 Symbolic Images*, 陽之陽爲太陽 陰之陰爲太陰 陰之陽爲少陽 陽之陰爲少陰.

²⁶ The 11 10 01 00 of binary logic, that is, the idea of binary code, explains the logical structure in the fields of addition, subtraction, multiplication, division and four arithmetic operations $+$ $-$ \times \div , propositional truth calculation table T F, computational mathematical circuit calculation, ASCII code, and gene sequence code. From Leibniz to Boolean, it is explained that the mathematical principle that identifies computer serial circuits was created through the algebraization of the logic of the symbolic system of 0 and 1 and the mechanization of

²¹ sillok.history.go.kr/. In 1708, he produced *Complete Geographical Map of Ten Thousand Countries* by M. Ricci and A. Shall and presented it to King Sukjong.

²² sillok.history.go.kr/.



Consequentially, he decompose the traditional mathematical classic book of *The Nine Chapters on the Mathematical Art* 九章算術 into an algorithm addition/subtraction/multiplication/division according to changes of the 4 *Symbolic Images*, where *Bangjeong* 方程 belongs to the *Old Sun*, *Sokmi* 粟米 and *Sogwang* 少廣 to the *Young Moon*, *Sanggong* 商工, *Gyunsu* 均輸 and *Youngyook* 盈朒 to the *Young Sun*, *Soebun* 衰分, *Bangjeon* 方程, and *Gugo* 勾股, to the *Old Moon*, where the *old sun*, the *Young Moon*, the *Young sun* and the *Old Moon* represent Indices of their phenomenal movement. In other words, the sun, the moon, planets and stars represents the number of *primeval element* 元數, the number of *law* 法數, the number of *appearance* 顯數 and the number of *disappearance* 隱數. The *Sun Index* plays the role of accumulation, the *Moon Index* plays the role of diminish, the *Young Sun Index* plays the role of increase, and the *Young Moon Index* plays the role of decrease. For each number, in order, first rule is the *Sun Index* that rises in turn, second rule is the *Moon Index* that divides in turn, third rule is the *Young Sun Index* that rises each other, and fourth rule represents the *Young Moon Index* that lowers each other and disappears.

calculation. The fact that it has been shown that it can be.



division of <i>The Nine Chapters on the Mathematical Art</i>				
object	sun	Moon	planets	stars
images	=	==	==	==
algorithm	addition	subtraction	multiplication	division
function	accumulate	diminish	increase	decrease
name of number	origin 元	law 法	appearance 顯	Disappearance 隱
name of images	Old Sun 老陽	Young Moon 少陰	Young Sun 少陽	Old Moon 老陰
division	Bangjeon 方田	Sokmi 粟米	Sanggong 商工	Gvunsu 均輸

According to this calculation, is law 法 formulate with practice 實, formula is $\frac{\text{practice}}{\text{law}}$.

If we use method of multiplying different things 異乘 and dividing the same things 同除, we can calculate the new astronomical system.²⁷

We ask and answer how many days are in a year and how many years are in 365 days, if a year is 12 months and a month is 30 days. When the number used in both system is set to $a:b = c:x$, equal things are multiplied 同乘 and different things are divided 異除. The same/same is $ax = bc$ and difference/difference is now $x = \frac{bc}{a}$ or $x = \frac{b}{a}(c)$.

$$\frac{\text{origin number}}{\text{appearance number}} = \frac{\text{law number}}{\text{disappearance number}}$$

$$\text{disappearance number} = \frac{\text{law number} \times \text{appearance number}}{\text{origin number}}$$

S. J. Choi relates with the formal $\frac{\text{origin number}}{\text{appearance number}} = \frac{\text{law number}}{\text{disappearance number}}$ change of all things to 4 Symbolic Images in Yum Yang. He cites the 11th chapter of I Ching that says when 1 is a Supreme Polarity 太極, 1 gives birth to 2 Modes 兩儀, and 2 Modes 兩儀 gives birth to 4 symbolic Images 四象.²⁸ Calculating with addition/subtraction/multiplication/division to respond to phenomenal movement of the sun, the moon, planets, and stars, S. J. Choi called the method of building Yum Yang as heaven earth bridge with 16 trigrams the Sun Index. According to interpretation of Jiaxian's Triangle, he represents the Sun Index as a- process of Yum Yang advances and retreats by taking heaven ○ in the first column, earth ●● in the second column, heavens ○○○ in the third column, etc. and 16 heavens ○ in the last 16th column. From 1 to 16, the heaven earth bridge of ●○ of the Sun Index infers an Yum Yang binary process.

○:heaven ●:earth S. J. Choi's Sun Index

²⁷ Lee Sang-gu, Lee Jae-hwa (2015), 75.

²⁸ <https://ctext.org/book-of-changes/xi-ci-shang/zh>.



calculates phenomenal movements of the sun, the moon, planets and stars through the binary reading method of *Yum Yang* prognoses.

S. J. Choi disassembled the bridge of heaven and earth between the sun, the moon, planets and stars with a clear self-consciousness of 0 and 1 for ●○ into the 4 *Symbolic Images* with addition/subtraction/multiplication/division. The *Yellow River Diagram* and the *Inscription of the River Luo* were two cosmological diagrams. S. J. Choi integrated it in a triangular form that calculated the sum of these heaven and earth bridges and called it *Descent Variable of the Yellow River diagram and Inscription of the Luo River* 河洛變數.

The root of *Yellow River Diagram* lies in a number group of 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, where 1, 3, 5, 7, and 9 are called *heavenly numbers* 天數, and 2, 4, 6, 8, and 10 are called *earthly numbers* 地數.³⁵ So, the *Yellow River Diagram* uses only numbers from 1 to 10. In this number system, an odd number is called a *positive number* 陽數, and an even number is called a *negative number* 陰數. The bridge of heaven and earth goes through crossing numbers of *Yum* and *Yang*. The numbers of heaven are 1, 3, 5, 6, 7, 6, the numbers of earth are 2, 4, 6, 8, 10. The whole sum of heaven numbers is the sum of positive numbers, and the whole sum of earth numbers is the sum of negative numbers. The number of heavens and the earths occur as the sum and difference of the numbers of *Yum* and *Yang*. The sum of heavenly numbers is 25, the sum of earthly numbers is 30. heavenly numbers. 1, 2, 3, 4, 5 are *numbers of life* 生數, 5, 7, 8, 9, 10 are *holy numbers* 成數. The former number raises birth to the latter numbers, if it is added from 5. It means that the latter numbers come from the addition of 5. If 5 is located to the center, 1 to north, 2 to south, 3 to east, 4 to west, man gets all directions from the center. The east is $5+3=8$, the west $5+4=9$, south $5+2$, north $5+1=6$. The *numbers of life* receives their values from the

position of the center in rectangle. The number of center 5 is located in center, where 1 is to north, 2 to south, 3 to east, 4 to west. If they are added by the number of 5 by overlapping, they get *holy numbers*. From the center 5, happens east $5+3=8$, west $5+4=9$, south $5+2=7$, north $5+1=6$.³⁶

The root of the *Inscription of the Lou River* lies in a number group of 1, 2, 3, 4, 5, 6, 7, 8, 9. When 5 is located at the center, (3, 8) is earth, (2, 7) is west, (4, 9) is south, (1, 6) is north. Since the *Inscription of the Luo River* exchanged the south and west locations of the *Yellow River Diagram*, a magic square is formed by creating direction where the sum of the horizontal, vertical, and diagonal lines is 15. If the center is earth, happens the north as winter, the south as summer, the east as spring, and the west as autumn. 1, 2 and 3, 4 take opposite properties, and north-south and east-west are symmetrical. With 5 as the center, the *Yum* and the *Yang* are placed on the left, the *Yang* on the right, the *Yang* on the top, and the *Yum* on the bottom. One week of Sun Moon Tue Wed Thu Fri Sat gives birth to the direction of the Sun, the Moon, and Five Stars.

³⁵ <https://ctext.org/book-of-changes/xi-ci-shang/zh>. 天一地二，天三地四，天五地六，天七地八，天九地十。

³⁶ <https://ctext.org/book-of-changes/xi-ci-shang/zh>. 天數五，地數五，五位相得而各有合。天數二十有五地數三十，凡天地之數，五十有五。



The Yellow River Diagram 河圖			The Inscription of Luo River 洛書				
	5+2 south			5+4 south			
5+3 east	5 center	5+4 west	5+3 east	5 center	5+2 west		
	5+1 north			5+1 north			
				magic square			
						4 9	2
						3 5	7
						8 1	6

The perspective orientation of the I Ching lies in working by assigning the 8 Trigrams to the 8 directions of east, west, south, north, northeast, southeast, southwest, and northwest, and allocating four seasons to the east, west, south, and north, centered on the center. The center is stationary, the north is winter, the south is summer, the east is spring, and the west is autumn.

The methods of addition number, subtracting number, multiplying number, and dividing number are called *Ga* 加, *Gam* 減, *Seung* 承 and *Jae* 除. So the method of addition/subtraction/multiplication/division helps to read the movement in all directions. S. J. Choi shows the calculation of *Sun Index* according to the heaven earth bridge of the sequence from the first term to the last term, while decomposing 1 to 16 into Yum and Yang as odd number and even number. First, the first term is removed, and the 1 that is not used is called *Gam* that means ① $16 - 1 = 15$. Then, the sum of the second term and the last term is taken added as *exponent* 賈,

and it is called *Ga* that means ② $3 + 15 = 18$. Multiplying the *exponent* term by the added term is the *Seung* that means ③ $15 \times 18 = 270$. Finally, divide 270 in half is *Jae* that arrives at ④ $170 \div 2 = 135$. The conclusion is $135 + 1 = 136$. As 0 is first term, the expression for summing zero to n terms of natural numbers is $S = \frac{n(n+1)}{2}$. In this equation, if n is even, this number (n + 1) odd, and if n is odd, then n + 1) is even.³⁷

S. J. Choi wrote down also without any other proof according to model of Jiaxian's Triangle following number series *gyochota* 郊草塚 1,2,3,4,5, ..., etc., *samgagta* 三角塚 1,3,6,10,15, ..., etc., *salseonghyeongta*

³⁷ As 0 is first term, the expression for summing zero to n terms of natural numbers is. In this equation, if n is even, this number is odd, and if n is odd, then n is even.



1,4,6,10,20, ..., etc., *samgalsseonghyeongta* ≡
 角撒星形塚 1,5,15,35,70, ..., etc.,
samgalsseongnagilhyeongta ≡ 三角撒星落一形
 塚 1,6,21,56,126, ..., etc.

In a same way Leibniz obtained also in his memorial notes during his discovering time of his calculus, natural numbers (1,2,3,4,5, ..., etc.), triangular numbers (1,3,6,10,15, ..., etc.), square numbers (1,4,9,16,25, ..., etc.), pentagonal numbers (1,5,12,22,35,51,70, ... etc.), hexagonal numbers (1,6,15,28, 45,66,91, ... etc.), and heptagonal numbers (81,112, ... etc.). He

discovered a harmonic triangle that divides π into quarters while taking the reverse order of Pascal's Triangle in the problem of finding the sum of a sequence of fractions with the encouragement of C. Huygens. His harmonic triangle is the reciprocal of Pascal's trigonometric sequence.

Although S. J. Choi suggested these sequences without proof, judging from this record, it shows that traditional oriental mathematics developed in Joseon in an independent phase different from Western mathematics.

Leibniz's Harmonic Triangle									
				$\frac{1}{1}$					
			$\frac{1}{2}$		$\frac{1}{2}$				
		$\frac{1}{3}$		$\frac{1}{6}$		$\frac{1}{3}$			
	$\frac{1}{4}$		$\frac{1}{12}$		$\frac{1}{12}$		$\frac{1}{4}$		
$\frac{1}{5}$		$\frac{1}{20}$		$\frac{1}{30}$		$\frac{1}{20}$		$\frac{1}{5}$	
Jia Xian's Triangle & Pascal's Triangle									
				1					
			1	1					
		1	2	1					
	1	3	3	1					
	1	4	6	4	1				
	1	5	10	10	5	1			
1	6	15	20	15	6	1			

Jia Xian's Triangle & Pascal's Triangle												
						1						
					1		1					
				1		2		1				
			1		3		3		1			
		1		4		6		4		1		
	1		5		10		10		5		1	
1		6		15		20		15		6		1

5. The Origin of the Round Square Diagram of 64 Hexagrams³⁸

³⁸ Leibniz said, in his *Memoires de l'Academie Royale des Sciences* in 1703, on pages 85-89, that reckoning of arithmetic people routinely wrote decimals as 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. Ten times ten times to make 100, ten times one hundred times to make one thousand, ten times one thousand times to make ten thousand. If plus 110+110=1101, 110+1011=10000,

1110+10001=11111, then 6+7=13, 5+11=16, 14+17=31. If 1110+10001=11111, then 14+17=31. Subtract 1101-111=37 is 13-7=6, 1000-1011=101 is 16-11=5, 1111-10001=1110 is 31-17=14. If $11 \times 11 = 1001$, $3 \times 3 = 9$, $101 \times 11 = 1111$, then $5 \times 3 = 15$, $101 \times 101 = 11001$ is $5 \times 5 = 25$. Divide by $15 \div 3 = 5$. J. Bernoulli congratulated the year 1701 as Leibniz's discovery of the binary system by reading binary numbers as 110010101101.



It was in 1673 that Leibniz produced the arithmetic $+ - \times \div$ calculating computer, and the paper dealing with the binary system of 0 and 1 was published on March 15, 1679 *De progressionem Dyadica* to be. Upon receiving J. Bouvet's letter on April 1, 1703, Leibniz personally read Fu Xi's *64 Hexagrams*, which are illustrated with a circle inside a square. The binary system was a part of the method of expressing numbers such as the quaternary system and the hexadecimal system, which Leibniz already considered. Leibniz replied an answer within a week and sent a thesis *Explication de l'Arithmetique Binaire* to be included in the *Memoirs* of the Paris Academy to A. Bignon, secretary of the Paris Academy, and ten days later sent a letter to H. Sloane, secretary of the royal society, where he mentioned that binary number is a general symbol as *characteristica generalis* that can solve problems of the human thought alphabet.

Reading -- as 0 and — as 1, Leibniz said, “— is 1 as unity, and -- is enough to show 0 as a broken line.” “I sent it to J. Bouvet in Beijing two years ago, and he replied on November 4, 1701, and in the midst of communication, he deciphered the symbol system of the help with my suggestion,” and recognized “I Ching is the oldest monumental work of mankind on earth.”

These *64 Hexagrams* consist of a Yum -- and a Yang —, *4 Symbolic Images*, *8 Trigrams* and *64 Hexagrams*. The Yum and the Yang are 0 and 1.³⁹ The *4 Symbolic Images* are called the *Old Yum*, the *Young Yum*, the *Young Yang* and the *Old Yang* which are corresponding to == == == == in symbols and 00, 01, 10, 11 in binary notation. The *8 Trigrams* are ≡ ≡ ≡ ≡ ≡ ≡ ≡ ≡ in symbols, and 111, 110, 101, 100, 110, 010, 001, 000 in binary representation. When the *8 Trigrams* overlap in the heaven earth bridge, the *64 Hexagrams* of $(2^3)^2$ created. The direction of

1701 = 110010101101.

³⁹ <https://ctext.org/wiki.pl?if=gb&chapter=417193>.

八卦相錯，然後萬物生焉。是故一分為二，二分為四，四分為八，八分為十六，十六分為三十二，三十二分為六十四，故曰分陰分陽。

reading goes from left to right, bottom to top on the *Round Square Diagram*.

Leibniz points out that the function of binary number is “a means of discovering mathematical, philosophical, and theological truth.” He added the Greek phrase κάτω downward and άνω upward to read the direction of the circle diagrams below the original drawing. His reading way on the circular diagram goes up from the bottom counterclockwise to the top, and then from the bottom to the top in a clockwise direction, completing the *64 Hexagrams*.

According to S. J. Choi's reading method, there is a *Ga Gam* 加減, an increase or decrease from the lower *Gon* 坤 to the upper *Goo* 姤, until the *Yum* grows and the *Yang* disappears, and from the lower *Bok* 復 to the upper *Gun* 乾, there is a *Seung Jae* 乘除, until the *Yum* disappears as the *Yang* fills up. Since the *4 Symbolic Images* are counted from the numbers that have not come to the numbers that have already occurred, the round diagram says that the *Gun* is in the northwest and the *Gon* is in the southeast. If it goes out, it is *Yang*, if it goes back, it is *Yum*.

6. Conclusion

I Ching is a concept that cannot be easily translated from one culture to another culture, but converting the *Yum Yang* -- — to Arabic numerals 0 and 1 makes it read in binary. Since Leibniz reads Yum -- and Yang — as 0 and 1, he discovered a binary method of reading composed of *64 Hexagrams* of Fuxi's *8 Trigrams* overlapping. J. Bouvet shared the *Yum Yang* binary reading method in 1703 in a letter seeking approval from the original author when he encountered the first binary reading method for the *8 Trigrams* from Leibniz's letter to P. Grimaldi in 1698. In 1711, J. Bouvet dedicated *Cheonjonjibido* to Kangxi, which illustrated the number of the *Yellow River Diagram* and *Inscription of the Luo River* in binary in a form of triangle. S. J. Choi read also the operation by 0 and 1 as the *Yum Yang* image of ●○ without recognizing the *Yum Yang* reading of Leibniz and J. Bouvet's binary algebraic function.

He structured independently the *Yum Yang*



and 4 Symbolic Images by ●○ in terms of addition/subtraction/multiplication/division and produced the same Descent Variable of the Yellow River Diagram and Inscription of the Luo River regarding to J. Bouvet's Cheonjonjibido. The New Year's Greeting Card, which Leibniz illustrated binary the 16 trigrams, and the Solar Index, in which S. J. Choi decomposes the heaven earth bridge from 1 to 16 into ●○, are structurally the same. Leibniz's binary reading method and S. J. Choi's algorithm of ●○ reading with addition/subtraction/multiplication/division system have an intellectual source common in the computer age of digital civilization by four arithmetic operations $+ - \times \div$.

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