Symmetry of STRUCTURE

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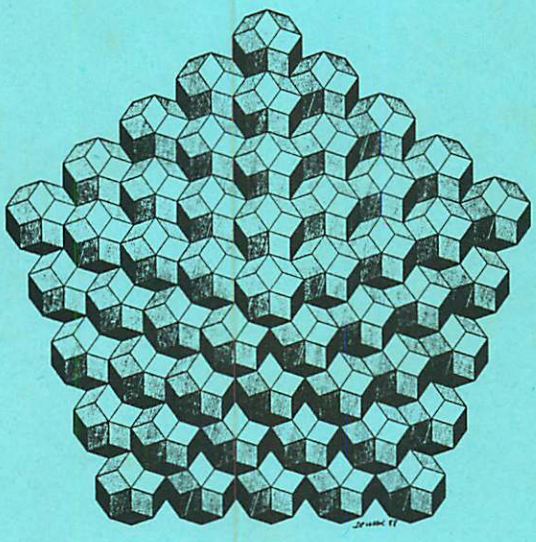
Abstracts

I.



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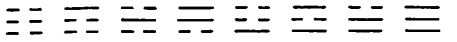
Binary and Cyclic Symmetries in Early Chinese Interpretation of Nature

Joseph Cheng-Yih Chen 程貞一

Department of Physics
University of California, San Diego, La Jolla, CA 92093
and
The Wei-Kung 爲公 Institute, La Jolla, CA 92037-0665

The abstraction of binary and cyclic patterns of nature occurred early in Chinese civilization.[1] In the course of time, binary patterns acquired the abstract significance of being associated with productivity and cyclic patterns acquired the abstract significance of being associated with continuity. Such abstractions formed the dynamic bases for the analyses of the processes of nature. The binary dynamics is governed by the 'yin-yang' 陰陽 principle while the cyclic dynamics is governed by 'i' 易 , the nature of 'yin-yang' changes.

An early symbolic representation of a binary system is found in the system of 'kua' 卦 constructed in terms of the 'yin' and 'yang', two types of symbols known as the 'yin yao' 陰爻 – – and the 'yang yao' 陽爻 —— . Taking n 'yao' at a time, the total number of combinations, allowing all possible permutations, is 2^n . We have, for example, the system of eight trigrams,



obtained by taking three 'yao' at a time.

The 't'ai-chi' 太極 model for productions of nature is found in the I Ching 《易經》 (Book of Changes)[2]:

是故易有太極，是生兩儀，
兩儀生四象，四象生八卦。

which in English reads[3]

> Therefore, in [the system of] 'i' 易 , there is the 't'ai-chi' 太極 (Primordial Pole) which produces two entities (i.e., the 'yin' 陰 and 'yang' 陽). These two entities produce four symbols and the four symbols produce the eight 'kua' 卦 (i.e., the trigrams).

Matthew Ricci interpreted the 't'ai-chi' as the 'materia prima' of the Scholastics.[4] John Rodriguez, later in 1631, made the following comments[5]:

> According to the Occidental interpretation, the Great Ultimate (i.e., the 't'ai chi') is something material, is matter without intelligence and without consciousness. Unless there is the infinite, omnipotent, wise, and intelligent factor, how could it ever produce things?

The fact that the 't'ai-chi' model for productions of nature contains no elements of creationism was a source of difficulty for occidentals in this early period of scientific revolution. The 't'ai-chi' model views productions as natural processes governed by the binary dynamics of the 'yin-yang' principle which are spontaneous, requiring no infinite, omnipotent, wise or intelligent factor.

The essential feature of the 't'ai-chi' model lies in the symmetry of the 1, 2, 4, 8 binary pattern. In fact, the statement for the 't'ai-chi' model given above is an algebraic statement of the 2^n binary expansion for n = 0 to 3. This symmetry is best illustrated in terms of the 'yin yao' and 'yang yao' symbols (see Fig. 1).

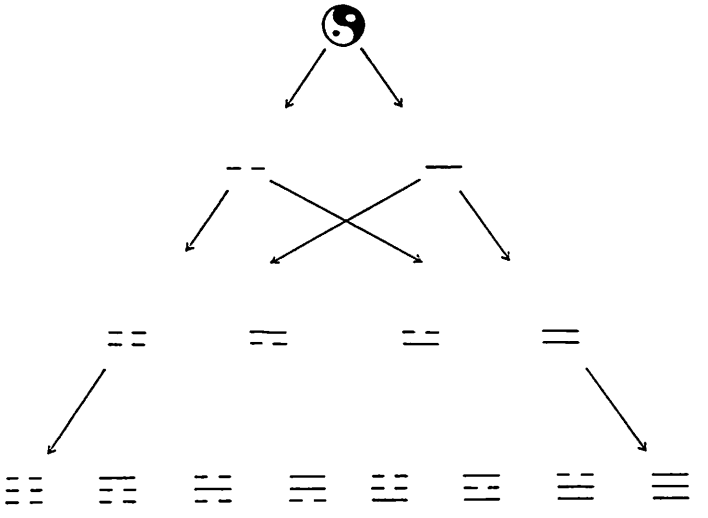


Fig. 1. The 't'ai-chi' model for productions of nature.

The algebraic nature of the binary expansion is evident since the elements in the expansion are open elements and may be variously substituted.

In favor of interpreting productions of nature as being ruled by chance, the early Chinese devised a divination procedure, known as the 'ta-yen' 大衍 procedure,[2] to consult with the 't'ai-chi' model. After the divinatory rhetorics are removed, the procedure may be stated as follows[6]:

(a) Divide the total 49 sticks into two portions arbitrarily and then remove one stick from one of the two portions.

(b) Count the sticks in each portion by fours, and then remove the remainders. (For the portion by fours evenly, take the remainder to be four.)

This simulation of the 2^n binary expansion certainly was intentional.

The question that one must address is whether the inventor of the 'ta-yen' procedure was aware of the mathematical content of his procedure. There is no question that the procedure was devised with the desire to simulate the binary symmetry of the 't'ai-chi' model. But this can be accomplished within the scheme of the procedure by simply imposing the appropriate conditions on the remainders resulting from counting the sticks by fours. The presentation of the procedure was, however, purposely made intriguing by aribtrarily allowing the division of the total number of sticks into two portions. To foresee the possibility of such a division necessitated an understanding of the mathematical content of the procedure. Despite the fact that the 't'ai-chi' model has long been superceded by other models, the use of symmetry in the model and the attempt to relate mathematics with the model at this early stage of our conceptualization of nature remains to be of great interest to the history of science.

Notes and References

1. Joseph Cheng-Yih Chen, lecture notes for Chinese Studies 170A entitled Scientific Thought and Intellectual Foundation, University of California, San Diego, 1981 (unpublished).

2. The citation is from 'Hsi-T'zu Chuan' 〈繫辭傳〉 ch. 11, pt. 1 of the Book of Changes.

3. There are several translations of this passage available in the literature. See for example, Richard Wilhelm 'I Ging'; Das Buch der Wandlungen (Diederichs, Jena, 1924), Eng. tr. C. F. Baynes (Bollingen-Panthenon, New York, 1950). The translation given here is the author's own, with supplied interpretations given in square brackets [ ] and explanations given in parentheses.

4. Fonti Ricciane D'Elia, Storia dell'Introduzione del Cristianesimo in China, Part II (Rome, 1949), p. 297, note b sqq.

5. These comments are from a letter written by John Rodriguez in 1631. The letter is still preserved at the library of the University of Seoul and has been published in the Shigaku Zasshi 《史學雜誌》 (The Historical Journal of Japan), vol. XLIV. The translation in English was made by Rufus Suter and Matthew Sciascia, see Pasquale M. D'Elia, Galileo in China (Harvard University Press, Massachusetts, 1960), p. 43.

6. Cheng-Yih Chen, lecture notes for Chinese Studies 170 entitled History of Mathematics in Chinese Civilization, University of California, San Diego, 1980 (unpublished).

(c) Take the remaining sticks (i.e., the total number of sticks minus those removed) to be the new total.

(d) Repeat the procedure two more times.

In current algebraic notations, the 'ta-yen' procedure may be written in terms of the following equations[6]

$$(1) \quad x = 4n_1 + R_1 + 1 , \qquad 4 \geq R_1 > 0$$

$$(2) \quad y = 4n_2 + R_2 , \qquad 4 \geq R_2 > 0$$

where n_1 and n_2 are positive integers, R_1 and R_2 are the remainders to be removed, and $x+y$ is the total number subject to the procedure.

Beginning with the number 49, we have $x+y = 49$. Eqs. (1) and (2) then reduce to

$$4n + R = 48 , \qquad 8 \geq R > 0$$

yielding two possible solutions

$$n = 10, \ R = 8 ;$$
$$n = 11, \ R = 4 .$$

This gives two possible paths, the path associated with the first solution with the number 40 and the path associated with the second solution with the number 44. The procedure is then repeated with one of the two numbers to generate the next possible paths. It is significant that the 'ta-yen' procedure allows a random generation of the paths and the paths so generated simulate the 2^n binary expansion (see Fig. 2).

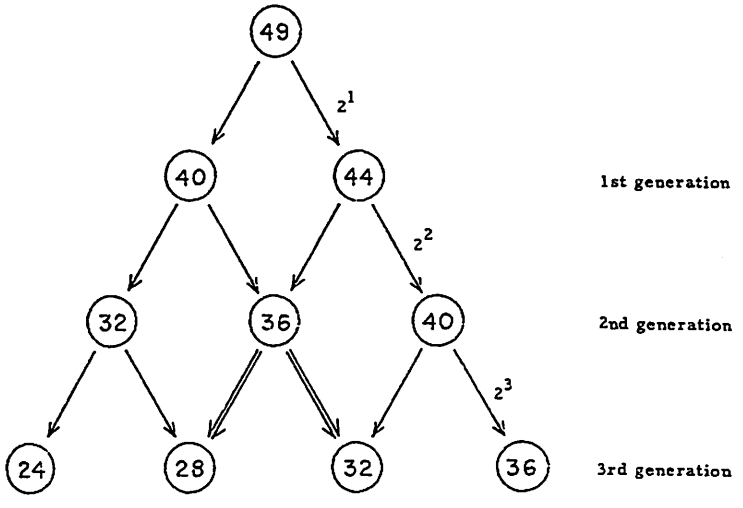


Fig. 2. The 2^n binary expansion for the paths generated by the 'ta-yen' procedure.

Alexander I. Chepalov
Kharkov, USSR

MEYERHOLD'S BIOMECHANICS: HISTORY OF THE TERM AND ITS RELATIONS WITH CONTEMPORARY SCIENCE

"Man - machine" metaphor came into existence as early as in the I8th century in the epoch of French materialism. The metaphor was becoming a reality while machine constructors started imitating living organism employing the language of their contemporary technology. In I920ies in the Soviet Russia certain social conditions were such that "man - machine" formula came into use in the ordinary sense of the word. It was connected with the necessity of quick speeding up labour productivity, with the strive for the soonest scientific and technological progress following the social revo - lution.

Artistic culture of that period should be regarded in the context of scientific and technological thought. This opinion has been reaffirmed by the experience of studying theatrical art of I920ies, especially the works on biomechanics by the great theatre producer V.E.Meyerhold (I874 - I940).

In I922 Meyerhold was lecturing at the Higher State Theatrical Studios and called his pupils assistants as if they were employees of a scientific research institution. Meyerhold's experiments in stage direction and theory of theatrical education were akin to those of Central Labour Institute founded in I92I where the outstanding neuro- and psycho-physiologist N.A.Bernstein was working.

The genesis of the term "biomechanics" has not been comple - tely cleared out in the Soviet science. The first Russian hand - book on the subject was published in I926 (Bernstein N. Biomechanics for Instructors). The author defined biomechanics as a science dealing with the way "the living machine, i.e. every human being, is constructed, what the design of its moving parts is, how they work".

Meyerhold's biomechanics in everyday meaning of the term had come into being even earlier. It was a school for training

actors and a practical system of their stage existence. He put forward an idea of "showing perfectly organized human mechanisms on the stage".

Another stage producer of theatrical avant-garde F.M.Foregger (I892 - I938) was developing - parallel to Meyerhold's biomechanics- his own system of theatrical and physical training. His demonstration of perfectly organized movement resulted in the imitation of labour process, of various productive mechanisms operations and was called "machine dances". "Machine dances" were actors group formations with various types of symmetry. Looking-glass-like similarity of performers' groups was stressed by uniformity of their accentuated geometrical costumes. Actors were imitating the work of transmission, rotating shafts, the movement of driving-belts, transporters, pistons, wheels. Complex combinations of simultaneous turns, gestures and movements of arms, legs, trunks, heads were included in a geometrical stage volume and were carried out in accordance with the rules of rotary and translational symmetry. Coordinate axes in this movements system were stage dimensions. Performers' physical actions were constructed according to mathematical laws deduced from living nature observation, from biological systems by productive mechanisms inventors. In "machine dances" these laws were visually demonstrated by people.

Accurate and reasonable movements were, thus, subjected to the one and the same algorithm defining the essence of a device operation, of a machine detail, of their dynamic peculiarities.

Biological symmetry laws and accentuated geometrical forms in the epoch of I920s constructivist art had their logical meaning, distinct esthetic ideals and social landmarks. From theatrical biomechanics point of view, these exercises were important for defining an actor's physical actions morphology, studying interconnection of movement elements and perfectioning performers' technique.

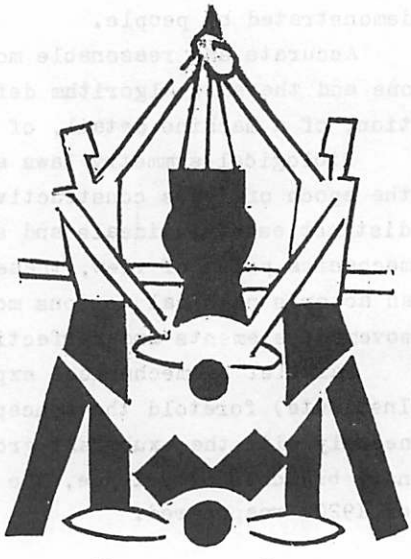
Parallel biomechanical experiments in science (Central Labour Institute) foretold the concept of cybernetics. In I960s, simultaneously with the exuberant growth of cybernetics and interdisciplinary branches of science, the interest towards theatrical experiments of I920s reappeared.

as well as some peculiarities of complex artistic thinking and scientific approach of modern prominent figures of stage towards the problem of creation.

From modern scientific point of view, Meyerhold's biomechanics and Foregger's "machine dances" have helped to define structural mechanisms of biological mobility. For them movements and structure symmetry was a device for studying and creating beauty, purposefulness and perfection in a given epoch. Movements algorithms were determined by dynamics of modern processes.

In present conditions of complex approach towards art and progressive theatrical figures' scientific thinking, artistic problems algorithms are becoming still more complicated. Complex symmetries concept helps modern artists to realize new esthetic principles of the late 20th century.

The main ideas of the present extended abstract have been presented by the author in the article "Theatre is a non-euclidian space" published in the magazine "Theatre" (1986, N II, p. 161 - 169).



Механические танцы Фореггера.