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The four directions of ancient Chinese thinking modes and their applications: Reflections based on "Einstein's Statement"

Danfeng Zeng*, Shengfeng Wang and Lushan Xiao

School of Marxism, Zhaoqing University, 55 Zhaoqing Ave., Duanzhou District, Zhaoqing, 526061, China.

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Abstract

Starting from the interpretation of the "thinking mode" within the discourse system of ancient China, this paper analyzes four distinct directions of the primitive dialectical thinking modes that emerged from the life essence of traditional Chinese culture and their applications. These are: the systematic thinking mode of the Circular Path inspired by the *I Ching* (Yi Jing) and its application in the manufacture of ancient Chinese wheels; the imagery thinking mode inspired by Yi zhuan (Commentaries on the I Ching) and its application in the production of tools for daily life; the intuitive thinking mode nurtured by Daoist philosophy and promoted by Daoism, leading to the medicinal use of alchemical findings; and the rational thinking mode fostered by Song-Ming Neo-Confucianism, which contributed to the development and technical improvements of the three great inventions of ancient China.

Keywords: Ancient China; Thought and Culture; Thinking Mode; Directions; Application

1. Introduction

According to historical records, from the 6th century to the 15th century AD, China consistently led the world in science and technology. However, following the 16th century, as Western science and technology rapidly advanced, ancient and civilized China began to fall behind the West. The reasons for this are widely debated. In a letter to Schweitzer in 1953, Einstein wrote: "The development of Western science was based on two great achievements, namely: the invention of formal logical systems by Greek philosophers (in Euclidean geometry), and the discovery of the possibility of establishing causal relationships through systematic experimentation (during the Renaissance). In my view, Chinese sages did not take these two steps" (Einstein, 1977, p. 574). In this paper, this is referred to as "Einstein's Statement."

If Einstein's statement holds true, then how did ancient Chinese science and technology, lacking the support of formal logical systems and experimental methods, come into existence and progress, eventually leading the world for such a long time? "The entirety of human culture, including natural sciences, at least has two major origins: one Western, one Chinese" (Liu, 2008, Preface). Thinking mode is an important component of culture, and the ancient thinking modes nurtured by the life essence of traditional Chinese culture formed a unique system that developed in parallel with Western thought. This thinking system underpinned the development of ancient Chinese science and technology. The present paper focuses on analyzing four distinct directions of the primitive dialectical thinking modes cultivated by traditional Chinese culture and their practical applications.

2. Interpretation of "Thinking Mode" in Ancient Chinese Discourse System

"Thinking mode" is a historical concept that evolves with social and historical development. Its understanding and recognition have deepened continually, making it difficult to provide a strict definition. Therefore, it is only by situating

* Corresponding author: Danfeng Zeng

"thinking mode" in the specific discourse system of ancient China and analyzing it accordingly that we can objectively and accurately grasp the object under study.

The term "thinking mode" originated in modern Western philosophy as a translated term from the English phrase "Thinking Mode." What constitutes a thinking mode remains a topic of debate in the academic community, with no clear definition to date. Tian Yun described thinking mode as a "specific mode of thinking that embodies certain ideological content and cognitive methods" ,also noting it as "a way of thinking in which the specific provisions of the thinking content are included" (Tian, 1998, p. 4). Zhou Lisheng examined it from a logical perspective, proposing that thinking mode is "an overall program of thinking that is constrained and regulated by a series of fundamental concepts" ,while from a historical perspective, he asserted that the thinking mode as theoretical thinking "has distinct characteristics of both its time and ethnicity" (Zhou, 2005, in Preface). Gao Chenyang analyzed the term from a methodological perspective, interpreting "thinking mode" as "a specific way for the subject to grasp the object" ,which, in its connotation, refers to being comprehensive or analytical, logical or intuitive, abstract or iconic—reflecting the processes and rules of thought mentioned above (Gao, 2012, p. 5). In this paper, the "thinking mode" refers to the fixed thinking patterns, paradigms, or methods that connect the subjective consciousness to objective objects. It is a result of the constant enhancement of the human brain's consciousness and abstract thinking ability. Moreover, it represents the external manifestation of the intrinsic processes of brain activity and the underlying psychological structures of the human mind, influenced by natural conditions, social environments, as well as cultural and ideological influences. It belongs to the category of philosophical methodology, characterized by historicity, ethnicity, and stability.

Although there is no specific term for "thinking mode" in ancient Chinese discourse, it does not mean that the ancient Chinese people did not possess a thinking mode. They indeed had their own thinking patterns, paradigms, and methods when understanding and connecting with the object. For instance, Kao Gong Ji states: "Heaven has its time, Earth has its qi, materials have their beauty, and crafts have their skill. Only when all four elements are in harmony can something be deemed good. However, if the material is beautiful and the craft is skillful but not good, it means it was not the right time or did not receive the Earth's qi" (Tian, 1998, p. 4). Ancient Chinese people believed that the harmonious blending of the elements of time, Earth's qi, material beauty, and craft skill constituted the standard for standardized craftsmanship, and this forms a thinking paradigm—i.e., the pattern of thought and method adopted by the subject in grasping and connecting with the object of standardized artistry or skills. Additionally, the Kao Gong Ji's records of the six proportions of bronze are considered classics of ancient Chinese metallurgical technology. The text notes: "Divide the metal into six parts and mix one part tin, this is called the alloy for bells and cauldrons; divide the metal into five parts and mix one part tin, this is the alloy for axes and chisels; divide the metal into four parts and mix one part tin, this is the alloy for halberds and spears; divide the metal into three parts and mix one part tin, this is the alloy for big blades; mix two parts tin for five parts metal, this is the alloy for arrowheads; and for the mirrors and fire tools, the tin should be equal to the copper" (Wenren, 2008, p. 41). This defines six standardized ratios of copper and tin in the bronze alloy smelting process, where the higher the tin content, the lower the grade of the alloy, and vice versa. This established a fixed paradigm of metallurgical thinking in ancient China, which had a profound impact on later generations.

Moreover, the yin-yang Eight Diagrams of Zhou Yi and the "Tai Chi Diagram" constructed by Neo-Confucian scholar Zhou Dunyi are general schemata that ancient Chinese people created to represent the objective world. These diagrams served as a priori models that guided subjective consciousness in grasping and connecting with the objective, thus demonstrating the significance of thinking mode.

3. The Four Directions of Ancient Chinese Thinking Modes and Their Applications

Gao Chenyang, in his reflections on traditional culture, pointed out that thinking mode represents the deepest and most essential part of national culture, permeating all aspects of social practices (Gao, 2012, Introduction). The ancient Chinese thinking modes were nurtured within the life essence of traditional Chinese culture and developed along four fundamental directions. These thinking modes were internalized by the ancients and applied in the manufacture of tools and the invention and improvement of technology.

3.1. The Circular Path Systematic Thinking Mode and Its Applications

The Circular Path, or *huandao*, refers to the concept of the cycle. The concept of *huandao* represents the cyclical and repetitive view of the world. While Western traditional thinking is often symbolized by a straight line, Chinese traditional thinking is represented by a circle. Western civilizations of antiquity used linear thinking to understand and transform nature, whereas the ancient Chinese developed a Circular Path thinking mode under the influence of the *I Ching*. This approach, complementary to Western thought, features comprehensiveness, wholeness, and systematic properties, which were internalized as practical methods used in the manufacture of tools for daily life in ancient China.

3.1.1. The Circular Path View in the I Ching and the Systematic Thinking Mode

Lüshi Chunqiu • Huandao is one of the early works that discusses the Circular Path view. In *Lüshi Chunqiu • Huandao*: "The Heavenly Way is circular, the Earthly Way is square, and the sages model themselves upon this, establishing the upper and lower accordingly. How do we know that the Heavenly Way is circular? The essence moves up and down, circles around repeatedly, and does not rest anywhere, thus it is called the circular Heavenly Way." Here, the "circular" (*huan*) refers to "round", meaning "to surround" or "to encircle". *Huandao* originally referred to the regular motion of celestial bodies, which was later extended to represent the governance mode by which the rulers emulated the celestial movement in an unending cycle.

The *I Ching* was the first to integrate diagrams, texts, and symbols to express the view of the Circular Path. The *I Ching* is the first part of the important pre-Qin work *Zhou Yi*. Ruan Yuan, in *Jing Ji Zuan Gu*, pointed out that during the pre-Qin and Han periods, "Zhou" meant "circle", "encircle", and "repeat". For instance, in *Shan Hai Jing • Overseas West Classic*: "The Kingdom of Women is north of Wu Xian; two women live by the encircling waters". Here, "zhou" means "to surround". In *Chu Ci • Jiu Ge • Xiang Jun*: "The bird roosts atop the house, and the waters encircle beneath the hall". Here, "zhou" represents "circling movement". The *Zhou Yi* starts with the Qian Hexagram, and in *Shuo Gua*: "Qian is Heaven, which is circular". Therefore, "Zhou" in *Zhou Yi* implies "circular movement" or "repetition".

In *Yi zhuan • Xi Ci*: "Yi means symbol". "The symbols appear in heaven, and forms manifest on Earth". Xu Shen, in the Han dynasty, wrote in *Shuo Wen Jie Zi*: "The Secret Text says: 'The sun and moon represent Yi, symbolizing Yin and Yang'". Therefore, "Yi" in *Zhou Yi* refers to the movement of the sun and moon. In *Zhou Yi • Xi Ci II*: "When the sun goes, the moon comes; when the moon goes, the sun returns. The sun and moon push each other, and illumination is born. When cold goes, heat arrives; when heat goes, cold arrives; as cold and heat push each other, the year is completed". It is evident that *Zhou Yi* integrates hexagrams and sequences to explain the continuous cycles of heaven and earth, sun and moon, day and night, and the four seasons. *Yi Jing* simulates the objective law of universal cycles, establishing sixty-four hexagrams that systematically express the concept of the Circular Path.

In summary, *huandao* represents the "Way of Cycles". The Circular Path view holds that all things in heaven and earth follow an eternal cycle. Natural phenomena, social occurrences, and human activities all unfold within this cyclical movement (Zhang, 1982, p. 535). Under the influence of the Circular Path concept, the ancient Chinese viewed the *huandao* as an interconnected whole comprising elements such as heaven and earth, sun and moon, day and night, four seasons, organisms, and materials. In analyzing and investigating things, they emphasized the relationships, interactions, and movement laws among components and systems, focusing on the whole and the broader picture, thus generating a systematic thinking mode characterized by comprehensiveness, wholeness, and systematization.

3.1.2. Application of the Circular Path Systematic Thinking Mode: Craftsmanship and Technology of Pre-Qin Wheel Production

In the early stages of social civilization, human understanding tended to revolve around comprehensive and holistic forms. The linear thinking mode of the ancient West did not align well with the comprehensive thinking requirements of that time, which led to relatively slow development in their science and technology. In contrast, the Circular Path thinking mode of the ancient Chinese coincided with the demands of the era and influenced the design, craftsmanship, and technology of tools used in daily production and life. The "Wheel People" section of the *Kao Gong Ji* (Records of Examination of Craftsmen), compiled by the people of Qi during the Spring and Autumn and Warring States periods, details the design and manufacture of wooden cartwheels in pre-Qin China, fully reflecting the Circular Path systematic thinking mode.

Kao Gong Ji • Wheel People records the procedures and craftsmanship of wheel production. First, three types of wood were harvested according to the appropriate season and used to make the "hub", "spokes", and "rim" of the wheel. "With the three materials ready, craftsmen harmonize them." Once the materials were prepared, they were processed and assembled by craftsmen to form a complete wheel. The "hub" is the central round wooden part of the wheel that enables it to rotate; the "spokes" are the straight wooden rods that connect the hub to the rim, and they must be installed perfectly straight and without deviation; the "rim" is the outer ring, essential for the wheel's endless rolling movement along flat ground, and "must be circular."

How can the craftsmanship of wheel production be considered perfect? When the wheel wears out, the hub, spokes, and rim should not loosen or deform, which is described as "perfect." Specifically, "When the wheel wears, the three materials do not lose their function, which is called perfect." The specific requirements are as follows: the "spokes", when viewed from afar, must be of uniform thickness like human arms, described as "balanced and slender"; when viewed up close, they must be "smooth and fine." The "hub", when seen from afar, must be even and polished, and up

close, the corners covered by leather must be firm and secure. If the inner side of the wheel's rim is properly aligned and the spokes and rim are perfectly straight, even if the wheel becomes worn, it will not deform.

A comprehensive analysis of wheel production reveals that the "hub", "spokes", and "rim" are three indispensable components (system elements) of a wheel. Each component (element) has specific production techniques and rules, and each step must meet specific requirements to fulfill its function. Then, according to the characteristics of the wheel's operation, the elements are reassembled and processed with meticulous craftsmanship, forming a structured and orderly whole that operates cyclically, constituting a complete wheel that serves its purpose. According to the author of *Kao Gong Ji*, the craftsman first decomposes the elements and structure of the wheel to understand their functions and requirements while also carefully grasping the interrelationships, restrictions, and dependencies among the components. This approach illustrates the application of the combination of system integration and detailed analysis in the Circular Path systematic thinking mode during wheel production.

3.2. The Imagery Thinking Mode and Its Applications

The imagery thinking mode is a rational thinking method that differs from Western abstract thinking while surpassing sensory perception. It is another direction of thinking modes nurtured by the imagery theory of *Yi zhuan* (Commentaries on the I Ching). The phrase "crafting by following imagery" highlights how this thinking mode is manifested in the manufacture of tools for daily life in ancient China.

3.2.1. Yi zhuan Imagery Theory and the Imagery Thinking Mode

The imagery theory is presented in the latter part of the *Zhou Yi*, known as *Yi zhuan*, which consists of ten chapters, including *Wen Yan*, *Tuan* (Parts I and II), *Xiang* (Parts I and II), *Xi Ci* (Parts I and II), *Shuo Gua*, *Xu Gua*, and *Za Gua*. In *Zhou Yi • Xi Ci I*: "Seeing is called imagery." In *Zhou Yi • Xi Ci II*: "When gazing upwards, one observes the imagery in the heavens; when looking downwards, one observes the methods on the earth" and "Symbols are formed in heaven, and shapes are formed on earth, and transformation becomes visible." In his annotations to the *Huangdi Neijing Yao Suwen*, Wang Bing of the Tang Dynasty wrote: "Imagery refers to what can be observed externally." Thus, the "imagery" in the imagery theory of *Yi zhuan* refers to the forms or phenomena of heaven and earth that manifest externally and can be perceived by the human senses.

In *Zhou Yi • Xi Ci I*: "Tuan speaks about imagery; yao speaks about change." "Tuan" refers to the names, hexagrams, and forms of the sixty-four hexagrams, which are used to symbolize the myriad entities in heaven and earth. Thus, "Tuan" also represents the "imagery" of heaven and earth that manifests externally: "Tuan speaks about imagery." "Yao" refers to the yang line (—) and the yin line (— —), representing the two symbols of yang and yin hexagrams. The yang hexagram represents firmness, and the yin hexagram represents gentleness. *Yi zhuan* says: "Softness above and firmness below, and the energies correspond with each other"; "Firmness and softness push each other, and change is within them." Thus, all things in heaven and earth are in a state of constant motion and interaction: "Yao speaks about change."

Thus, the imagery theory not only studies the static "imagery" of objects but also studies the dynamic "imagery" of behaviors, functions, and structures of objects. "Therefore, *Yi* is imagery, and imagery is resemblance." In other words, *Zhou Yi* speaks about hexagrams, and "imagery" involves using symbolic methods to mimic the characteristics of objects. Under the influence of the imagery theory, ancient Chinese imagery thinking was formed. Specifically, this thinking mode was based on the sixty-four hexagrams representing or symbolizing objects, with yang lines (—) and yin lines (— —) used as abstract symbols to represent the yin and yang attributes of objects. The hexagrams and yao served as elements of thought to create imagery models that symbolized the process of motion, change, development, and interaction of objects. The ancient Chinese used this imagery thinking mode, represented by the yin-yang Eight Diagrams of *Zhou Yi*, to invent and create tools, following the concept of "crafting by following imagery".

3.2.2. Application of the Imagery Thinking Mode: Manufacturing Tools for Production and Daily Life in Ancient China

From the perspective of the object of thought, the imagery thinking mode uses the "imagery" of objectively existing things as its raw material and elements. It differs from abstract thinking, which uses abstract concepts as units of thought, and from direct sensory perception, which tends to yield fragmented and superficial representations. In contrast, the "imagery" in imagery thinking is a processed, selected, and generalized representation formed by the mind. From the perspective of the thinking goal, abstract thinking aims to produce abstract concepts or categories, along with the corresponding reasoning and judgment. The goal of imagery thinking, however, is to generate new, typified images by using sensory image concepts and conformed symbolic thinking schemas—"establishing images to convey meaning"—which captures and links to the object by merging sensory images and conformed symbols.

Ancient Chinese people used the imagery thinking mode to construct visual models. On the one hand, these models explained and predicted the movements and changes of objective entities; on the other hand, they were used to invent and create writing systems, production technologies, and tools. For example, in *Yi zhuan • Xi Ci II*, it is recorded: "Fuxi created the Eight Trigrams to facilitate the moral power of spiritual clarity and to compare the sentiments of all things." This means that Fuxi created the Eight Trigrams to integrate the virtues of divine wisdom, assist in the creative processes of heaven and earth, and symbolize the states of all things.

For instance, the character "Li" in ancient Chinese oracle bone script features (as depicted below): a bird at the top and a long-handled net used to catch birds at the bottom. The image depicts a bird in a net, meaning "to catch a bird with a net." In *Zhou Yi*, the character "Li" in silk manuscripts is equivalent to "Luo." *Shuo Wen Jie Zi* defines "Luo" as "a silk net for catching birds, composed of threads and netting." The *Li* hexagram in *Zhou Yi* features two instances of *Li*, resembling intertwined knotted strings. Hence, Fuxi "made knotted strings to create nets for hunting and fishing, deriving it from the *Li* hexagram" (Yang & Zhang, 2011, pp. 607-609). Here, "罔(wang)" and "网(wang)" are synonymous, and "佃(tian)" is equivalent to "田(tian)" (farming). Therefore, Fuxi drew upon the imagery of the *Li* hexagram, tying ropes and weaving them into nets as tools for hunting and fishing.



Figure 1 "Li" in ancient Chinese oracle bone script features

Similarly, in *Zhou Yi*, the *Yi* hexagram is composed of the *Xun* trigram above and the *Zhen* trigram below. *Shuo Gua* states: "Zhen means movement", and *Zhen* represents thunder, which not only moves by itself but also sets all things in motion; hence, "Zhen" means "movement" (Yang & Zhang, 2011, p. 655). *Shuo Gua* also states: "*Xun* represents wood." Yang is active, Yin is still, and two yang elements are above, symbolizing leaves, while one yin element is below, symbolizing roots. Thus, "*Xun* represents wood" (Yang & Zhang, 2011, p. 663). Therefore, the imagery of the *Yi* hexagram represents "wood in motion." Consequently, Shennong "zhuo mu into plowshares and rou mu into plow handles; the efficiency of plowing with these tools benefited all people, deriving it from the *Yi* hexagram." Here, "zhuo mu" refers to chiseling, "si" is an ancient agricultural tool used for plowing, and "rou" refers to bending wood after heating it over a fire. "lei" refers to the plow, which is the curved handle at the top of the plowshare. Shennong skillfully drew upon the imagery of the *Yi* hexagram, chiseling wood and utilizing its physical properties to create plow tools for tilling fields.

Another example is the *Huan* hexagram in *Zhou Yi*, with *Xun* (wood, boat) above and *Kan* (water) below, resembling the image of traveling in a wooden boat. *Tuan Zhuan* states: "It is beneficial to cross great rivers, as boats are effective for this purpose" (Yang & Zhang, 2011, p. 509). Thus, Huangdi, Yao, and Shun "hollowed wood to make boats and sharpened wood to make oars. The effectiveness of boats and oars allowed for traversing inaccessible places, enabling people to reach distant lands and benefit the world." Huangdi, Yao, and Shun derived the imagery of the *Huan* hexagram to create boats and oars from wood, using them to float on water and serve as means of crossing rivers, allowing people to travel to distant places for the benefit of society.

The above examples are classic demonstrations of the application of the imagery thinking mode in the practices of Fuxi, Shennong, Huangdi, Yao, and Shun in inventing and manufacturing tools for production, daily life, and transportation based on the imagery of the hexagrams in *Yi zhuan*.

3.3. The Direction of Intuitive Thinking Mode and Its Application

The study of thinking can be "divided into three components: abstract (logical) thinking, image (intuitive) thinking, and inspiration (insight) thinking" (Qian, 1986, p. 16). Ancient Chinese intuitive thinking does not belong to any of these specific categories. Instead, it is an organic "combination" of image (intuitive) thinking and inspiration (insight) thinking. It is a relatively independent and unique thinking mode nurtured by ancient Chinese Daoist philosophy and

esteemed by Daoism. In practice, it facilitated the integration of alchemical refining for cultivation purposes with the techniques of medicinal drug manufacturing, advancing the medical application of alchemical experiences.

3.3.1. "Dao" and the Intuitive Thinking Mode

The concept of *Dao* is a crucial ontological and epistemological notion in ancient Chinese thought, representing the highest philosophical category proposed by pre-Qin Daoism. Intuition and intuitive thinking first originated from the understanding of *Dao* by ancient Chinese philosophers. For example, in *Laozi*, it is said: "Therefore, constant non-being enables one to observe the wonder; constant being enables one to observe the limit." Laozi argued that the profundity of *Dao* must be observed and comprehended from "non-being", and its clues must often be observed and felt from "being", because "these two emerge from the same source but have different names; they are called profound. Profound, and more profound, the gateway to all wonders." In Laozi's view, *Dao* is deep and mysterious, requiring the subject to grasp it through observation, as well as through the mind's intuition and perception. Here, "intuition" and "perception" are two forms of intuitive thinking. Another example is from *Zhuangzi • Ze Yang Chapter 25*: "Nameless and formless, existing in both the tangible and the intangible, expressible yet elusive, words cannot capture its essence... *Dao* is the ultimate of all things; words and silence are inadequate to convey it. Neither words nor silence can express its entirety." In this context, *Dao* exists both in the tangible and intangible. The presence of *Dao* is not in the external circumstances but within the mind. Words cannot fully express the profundity of *Dao*, and it can only be comprehended through sudden insight and perception. Zhuangzi believed that *Dao* was difficult to convey through language or literary embellishment, advocating instead the use of the intuitive forms of insight and perception to grasp the true meaning of *Dao*.

The development of intuitive thinking "began with Laozi and can be said to have matured with Zhuangzi" (Zhang, 1982, p. 535). As an internalized practical mode, it found expression in reality through Daoist metaphysics, which was highly revered and widely applied by Daoist practitioners. *Wu Shang Mi Yao* is one of the earliest extant Daoist texts advocating for intuitive thinking. For instance, in *Wu Shang Mi Yao • Lun Yi Pin*, it is stated: "The true nobleman is simple without embellishments; he does not perceive the world through vision or hearing but embraces the mystery." In other words, a true nobleman is plain and unadorned; he perceives things not with his eyes and ears but rather grasps the essence of things through intuition, similar to understanding the profundity of *Dao*.

Daoism, founded by Zhang Ling during the reign of Emperor Shun of the Eastern Han Dynasty, was based on Daoist theory, investigating the abstract and inexpressible transcendental *Dao*. It held "attaining the *Dao* and becoming an immortal" as its primary religious ideology, with the ultimate goal of achieving longevity and transcendence. The "mystery" in Daoist metaphysics is derived from the phrase "profound, and more profound" in *Laozi*. It is a textual expression of the ungraspable and limitless nature of the *Dao* in Daoism. The task of Daoist metaphysics was to guide Daoist followers into the profound realm of *Dao* through the direct experiential integration of mind and *Dao*. However, *Dao* is colorless, tasteless, silent, formless, and elusive; it is unfathomable and difficult to perceive with the senses. Thus, it requires individuals to use experience, wisdom, and insight to directly explore the essence of things. The logical process in this thinking mode starts by rationally grasping the objective laws of nature, leading to the individual's realization, understanding, and attainment of *Dao* at the level of subjectivity. The subject employs intuitive thinking forms such as "perception", "sudden insight", and "appreciation" to grasp the object, thereby achieving unity between subject and object. This intuitive thinking mode aligns with the Daoist goal of spiritual cultivation, and hence it was highly regarded by Daoist priests and practitioners.

3.3.2. Application of the Intuitive Thinking Mode: Medical Utilization of Alchemical Experience

Einstein believed that the mission of a physicist is to discover universal fundamental laws, but there is "no logical pathway to these laws; only intuition, resting on sympathetic understanding of experience, can guide" (Einstein, 1977, p. 135). Qian Xuesen also argued that in order to innovate and make breakthroughs, relying solely on image thinking and abstract thinking is insufficient—one must also have inspiration (Gao, 2012, p. 135). Einstein's "sympathetic understanding of experience" and Qian Xuesen's "inspiration" are different expressions of the ancient Chinese intuitive thinking mode. They reveal the inseparable relationship between scientific inventions and intuitive thinking. For example, Archimedes discovered the principle of buoyancy through inspiration derived from observing water's buoyancy; Newton discovered the law of universal gravitation through the inspiration triggered by the falling apple; Watt understood the power of steam from the lid lifted by steam and invented the steam engine. Intuitive thinking also played a significant role in the transformation of Daoist alchemical experiences into medicinal applications in ancient China.

Under the influence of intuitive thinking, Daoist alchemists transformed their alchemical experiences into a practical medicinal manufacturing system. Daoism underwent a process that evolved "from dreams and quests to practicing alchemy and rigorous cultivation" (Jiang & Tang, 2010, p. 66). During the Northern and Southern Dynasties, Daoism

entered a phase of rationalization, requiring the support of specific medicines and techniques, and sought to achieve the ultimate goal of attaining the Dao and becoming immortal through the practitioners' craftsmanship and capabilities. This stimulated and promoted the technological rationalization of Daoist intuitive cultivation practices and the development of their practical applications. For example, alchemical "elixirs" evolved into prescriptions for treating specific diseases, and "alchemical furnaces and cauldrons" were transformed into standardized instruments for the manufacture of medicinal substances. The alchemical ritual process was also converted into experimental and production procedures for medicinal substances, thereby creating a technical system for producing medical drugs. The construction of this system was the result of accumulated alchemical experience and its conversion into practical outcomes. This "conversion" often stemmed from a moment of "sudden insight" or "inspiration," akin to Einstein's "sympathetic understanding of experience" or Qian Xuesen's "inspiration." It represents the practical application of ancient Chinese intuitive thinking and its utilization in the field of medicine.

3.4. The Direction of Neo-Confucian Rational Thinking Mode and Its Application

Li stated: "In essence, Song Dynasty Neo-Confucianism was scientific, and, accompanied by it, came an unprecedented flourishing of activities in pure science and the application of science itself" (Li, 1990, p. 527). By "scientific," Needham primarily referred to the scientific nature of *gezhexue* (the study of the investigation of things and the extension of knowledge) in Song and Ming Neo-Confucianism. *Gezhixue*, translated as "the investigation of things and extension of knowledge," was the term used by modern Chinese people to refer to natural science. Although the goals of *gewuzhizhi* during the Song and Ming Dynasties differ from the understanding of natural sciences in the modern era, its inherent scientific nature and the rational thinking mode it nurtured played a significant role in the advancement of science and technology.

3.4.1. Song-Ming Neo-Confucian Gezhixue and Rational Thinking Mode

Neo-Confucianism, also called *lixue* (the study of principle), was founded by the two Cheng brothers (Cheng Hao and Cheng Yi) of the Northern Song Dynasty, and further developed by Zhu Xi in the Southern Song Dynasty. In *lixue*, the concept of "li" (principle) replaced Laozi's "Dao." On the macro level, both "li" and "Dao" refer to the "laws" or "origin" of all things; however, on the micro level, each has its unique meaning. "Dao" refers to the fundamental or universal laws of all things, representing the most general laws and attributes of phenomena. On the other hand, "li" refers to specific or particular laws of individual things, including their essential properties, structure, and concrete forms. It is also the attribute that distinguishes different things. For instance, Han Feizi considered the specific forms such as "short and long, big and small, square and round, hard and brittle, light and heavy, black and white" to be within the scope of "li." He stated, "In every principle, there are divisions of square and round, short and long, rough and fine, hard and brittle; only after establishing the principles can one comprehend *Dao*" (Han Feizi, *Jie Lao*). In Zhu Xi's words, "*Dao* is the general name, and *li* refers to the detailed aspects"; "*Dao* encompasses the grand, while *li* contains many specific principles"; "*Dao* is vast, while *li* is meticulous" (Zhu, 2008, p. 237).

Neo-Confucians believed that the key to "exhausting principles" lies in "*gewuzhizhi*" (the investigation of things and extension of knowledge). Influenced by the principles of Neo-Confucianism, Song-Ming Neo-Confucians established the doctrine of *gewuzhizhi* (*gezhexue*) based on their epistemological concepts and methodological significance. Cheng Yi said: "*Ge* means to reach; it signifies the thorough investigation of the principles of things"; "*Ge* is the same as exhausting, *wu* is the same as principle, thus, it means to exhaust principles and nothing more. Only by exhausting the principles can one extend knowledge, if the principles are not exhausted, one cannot extend knowledge"; "*Zhizhi* means to fully understand. Exhausting principles through the investigation of things leads to the extension of knowledge" (Hu, 2013, p. 280). Here, "*gewu*" refers to "investigating the principles of things" or "exhausting principles to extend knowledge," while "*zhizhi*" means "fully understanding," signifying complete comprehension. Zhu Xi further stated that *gewuzhizhi* requires one to "understand meticulously, analyzing even the smallest parts."

In summary, *gewuzhizhi* can be understood as the multi-faceted, multi-layered, and multi-angled exploration and in-depth research of the *li* (principle or law) of things to achieve comprehensive knowledge of those things. It emphasizes the breadth and depth of understanding of the *li* of things, based on erudition, inquiry, and analysis to seek knowledge of laws. The rational thinking mode nurtured by Song-Ming Neo-Confucian *gezhexue* represents a direction in ancient Chinese thinking that most closely approaches the thinking of modern scientific and technological inquiry. Its logical process emphasizes studying, investigating, and analyzing the essential properties, internal and external structures, and concrete forms of things—"inside and out, the rough and the refined, leaving nothing untouched." It seeks knowledge of laws, classifies and organizes that knowledge, and thereby enhances the depth and breadth of understanding of objective things, which in turn leads to related inventions and technological improvements.

3.4.2. Application of the Rational Thinking Mode: The Three Great Inventions of Ancient China and Their Technological Improvements

Under the influence of the rational thinking mode, three of the four great inventions of ancient China were significantly improved and began to see widespread use. The Song and Ming Dynasties, particularly the Song Dynasty, represent a golden age of scientific and technological development in China.

Gunpowder is one of China's four great inventions. It was initially discovered by Daoist alchemists during their alchemical experiments. By the Tang Dynasty, scientists had mixed sulfur, saltpeter, and charcoal to create black powder. In *Zhenyuan Miaodao Yaolue*, it is recorded: "Mix sulfur, realgar, and saltpeter, and burn them together intensely," resulting in "flames that burn hands, faces, and houses." The famous alchemist and physician Sun Simiao recorded in *Sun Zhenren Danjing*: "Mix sulfur, potassium nitrate, and charcoal to make gunpowder." By the Song and Ming Dynasties, under the influence of rational thinking, Chinese scientists conducted in-depth research into the properties, composition, and delicate proportions of black powder. They achieved a more reasonable quantitative ratio, adjusting the original mixture of 75% saltpeter, 10% sulfur, and 15% charcoal to a new ratio of 75% saltpeter, 11% sulfur, and 14% charcoal, enhancing its function from "combustibility" to "explosiveness" (Baidu Baike, n.d.). The explosive force of gunpowder was then used to develop firearms, such as guns, rockets, and shells, which were widely used in military applications.

The compass is another major invention of ancient China. Guided by the internal mechanism of rational thinking, ancient Chinese scientists gained a deep understanding of the inherent properties of magnets and steel (used for needles). They studied and fully utilized the essential attributes, internal structures, and interactions between natural magnets and steel to create a magnetic pointing device. The principle behind the compass is to use the magnetism of lodestones and the effect of magnetic fields to align the magnetic domains of a steel needle, thereby giving it a directional function. Initially used in geomancy and Feng Shui, the application of the compass expanded to navigation, enabling seafaring both during the day and at night, in all weather conditions. New maritime routes were continually opened, and by the time of Zheng He's voyages to the West during the Ming Dynasty, Chinese navigational science had reached its pinnacle.

Block printing was invented during the Tang Dynasty, and by the Song and Yuan periods, Bi Sheng had invented movable type printing technology. The highlight of Bi Sheng's invention was the use of clay to create movable type. The "movable" feature had several characteristics: first, it could be preserved; second, it was easy to disassemble and reassemble; third, it could be reused; and fourth, labels arranged according to rhyme were affixed to facilitate retrieval, saving time and effort and providing economic convenience. By the Yuan Dynasty, Wang Zhen invented the revolving typesetting table, improving typesetting technology. The principle behind this improvement was that wooden movable types categorized by phonetic rhyme were placed in compartments on a rotating table, allowing typesetters to easily retrieve characters by simply turning the table—"finding characters by moving the table, retrieving them by rhyme." Both Bi Sheng and Wang Zhen fully utilized the classification and categorization methods of the rational thinking mode in their technological improvements to the printing process.

4. Conclusion

In summary, the rational thinking mode played an essential role in the invention and improvement of the compass, gunpowder, and printing.

The four thinking modes described above represent the cultural genes of traditional Chinese culture and the external manifestation of Chinese intellectual activity. They did not act in isolation in the creation of tools and scientific inventions in ancient China but rather intersected and collectively propelled these advancements. However, these thinking modes were not without limitations. Their inherent constraints became increasingly evident in the context of the modern development of science and technology; they retained their primitive aspects and ultimately did not evolve into the systematic modern scientific approach.

Compliance with ethical standards

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References

- [1] Einstein A. *Collected Works of Einstein, Volume 1*. Beijing: The Commercial Press; 1977.
- [2] Liu C. *Chinese Systematic Thinking*. Beijing: Social Sciences Academic Press; 2008.
- [3] Tian Y. A preliminary analysis of thinking modes. *Guizhou Social Sciences*. 1998;(6).
- [4] Gao C. *Study on Traditional Chinese Thinking Modes*. Beijing: Science Press; 2012.
- [5] Wenren J. *Translation and Annotation of Kao Gong Ji*. Shanghai: Shanghai Ancient Books Publishing House; 2008.
- [6] Yang T, Zhang S. *Translation and Annotation of Zhou Yi*. Beijing: Zhonghua Book Company; 2011.
- [7] Qian X, editor. *On Thinking Science*. Shanghai: Shanghai People's Publishing House; 1986.
- [8] Zhang D. *Outline of Chinese Philosophy*. Beijing: China Social Sciences Press; 1982.
- [9] Jiang S, Tang WX. *History of Daoist Science and Technology: Northern and Southern Dynasties, Sui, Tang, and Five Dynasties Volume*. Beijing: Science Press; 2010.
- [10] Li Y. *Science and Civilization in China, Volume 2*. Beijing: Science Press; Shanghai: Shanghai Ancient Books Publishing House; 1990.
- [11] Han FT. Jie Lao.
- [12] Zhu X. *Zhuzi's Collected Works on Human Nature and Reason (including Collected Works on Xingli)*. Shanghai: Shanghai Ancient Books Publishing House; 2008.
- [13] Hu HK. *Twenty Lectures on Ancient Chinese Scientific Thought*. Beijing: University of Science and Technology of China Press; 2013.
- [14] Baidu Baike. Gunpowder [Internet]. Available from: <http://baike.baidu.com/subview/3606/5031653.htm?fr=aladdin>