Special Feature

A Comparison of Korean and Japanese Scholars' Attitudes toward Newtonian Science

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Introduction

In the nations of East Asia, western science, particularly modern science, has been considered as an essential prerequisite for their processes of modernization. Therefore, those who embraced and argued for the acceptance of facts and theories of western science have been considered pathfinders in their countries and have received much scholarly and popular attention. On the other hand, those who resisted western science or struggled to defend traditional knowledge of nature have been labeled conservative. For example, Korean scholars who accepted the earth's rotation, such as Kim Seokmun 金錫文(1658-1735), Yi Ig (1681-1763), Hong Daeyong 洪大容(1731-1783), and Choe Hangi (1803-1877), have received much attention. Likewise, early Japanese advocates of heliocentric world system, Motoki Ryoe 本木良永(1735-1744), Shiba Kokan 司馬江漢(1749-1818) and Shizuki Tadao 志筑忠雄(1760-1806), have received much scholarly attention and become objects of research.

However, it is problematic to assume that, because western science is nowadays considered to be modern and to consist of universal knowledge, all nations in all contexts must accept and embrace it. In fact, western science in premodern East Asia was context-dependent knowledge. Instead of understanding it in its own western context, intellectuals of premodern East Asia reinterpreted western science according to their own intellectual tradition and natural philosophy. Therefore, before asking how early and how much an East Asian intellectual accepted western science, we must discover how it was understood in the East Asian context and what meaning was granted to it.

Intellectuals of pre-modern East Asia often gave new interpretations to western science and used elements of western science as ingredients of their own ingenious thinking and arguments. In particular, Choe Hangi of Korea and Shizuki Tadao of Japan even interpreted and reinterpreted "universal" Newtonian science according to their own intellectual contexts. Using the traditional East Asian concept of "*gi* 氣" (energy) as the base concept, the two men reinterpreted concepts of Newtonian science and developed new and original thoughts in their natural philosophies.

I will argue in this article that western science in premodern East Asia was understood in the context of the East Asian intellectual tradition rather than that of the western context, using Choe Hangi of Korea and Shizuki Tadao of Japan as representative examples. To support my argument, I will focus on the concept of *gi*, which had been used as a key concept in East Asian natural

philosophy and with which the two intellectuals commonly engaged when they interpreted western science. I also focus on how the two intellectuals from Korea and Japan, respectively, perceived the concept of gravity, a key concept of the Newtonian science. The similarities and differences will be seen from the strategies the two intellectuals employed when they evaluated Newtonian science which focuses only on mathematical descriptions of physical phenomena, neglecting the explanation of the origin of gravity and the physical mechanism of gravitational interaction. Lastly, the two intellectuals' assessment of the concept of a supranatural God, the creator and authorizer of the universal order in the Newtonian science, will be compared. I will argue, then, that the origins behind the affirmation and negation of the concept of God lay in the two intellectuals' systems of thought.

Meeting Newtonian Science

The case of Choe Hangi

John Herschel's (1792-1871) *Outlines of Astronomy* (4th edition, London, 1851) was translated and published in Chinese under the title *Tantian* 談天 in 1859. This text, comprised of 18 main volumes and additional tables, was translated by British Protestant missionary Alexander Wylie (1815-1887) and Chinese mathematician Li Shanlan 李善蘭(1811-1882). John Herschel, whose father William Herschel (1873-1822) discovered Uranus, was a famous scientist and astronomer in Europe. *Outlines of Astronomy* (652 pages) is a revised and enlarged edition of Herschel's older work, *A Treatise on Astronomy* (1833, 361 pages), and sought to explain celestial phenomena based on the Copernican and Newtonian systems of astronomy without using advanced mathematical terminology (Cannon 1961:226). Twelve English-language editions were published between 1849 and 1873, and it was translated worldwide.

John Herschel's book is said to have combined the nebulae astronomy his father had developed and Newtonian physics (Cannon 1961:236). John Herschel sought to explain newly-discovered celestial objects and phenomena using Newtonian theories. *Outlines of Astronomy*, in particular, was recognized as a successful accomplishment in this regard. *Outlines of Astronomy* continued to be read widely as a "guide book" of the field, even among lay readers, into the 1930s.

Its Chinese language version, *Tantian*, was also widely read in China from its first publication in 1859. Alexander Wylie, in addition, published an enlarged version of the book with the help of Chinese scholar Xu Jianyin 徐建寅(1845-1901) in 1874. The 1874 edition included new astronomical discoveries and commentaries on them, as well as a biography of John Herschel. A number of different editions were published afterwards, including the Jiangnan Arsenal edition in 1879 (Zhu [1931]1933:19; Xu [1902] 2003:216-217). A translation of *Tantian* also appeared in Japan. Hukuda Riken (1815-1889) published it in 1861, after adding in the necessary punctuation marks.

It is likely that the first Korean who read *Tantian* was Choe Hangi. Although it is difficult to know exactly when he obtained a copy, I assume that he had obtained a copy by 1861, two years after its first publication in China. Based on the scientific knowledge garnered from this book, Choe Hangi expressed his own ingenious thoughts in his *Seonggi unhwa* ("Dynamic Change of Stellar Gi," 1867). Through this text, it is possible to discover how a Korean Confucian scholar engaged and responded to Newtonian science, a symbol of modern science of the West.

The case of Shizuki Tadao

Shizuki Tadao was born in 1760 to a wealthy Nagasaki family, the Nakano family. He later became an adopted son of the Shizuki family, a family that traditionally produced a number of Dutch interpreters. Following in the footsteps of his adopted father, Shizuki became the eighth-generation interpreter in 1776. However, Shizuki quit his job in 1777 due to illness, and focused on researching and translating Dutch language texts. He later became a great authority on the so-called *Rangaku* ("Dutch studies"), extensively researching and writing on western geography, astronomy, mathematics and physics. There are around 40 extant books written by Shizuki; *Kyūryokuhōron* and *Rekishō Shinsho* are representative ones that mainly touch upon Newtonian science.

Kyūryokuhōron and *Rekishō Shinsho* are based on the Latin writings of John Keil (1671-1721), an Oxford University professor in astronomy and avid advocate of Newtonian natural philosophy. Works of John Keil gained fame as popular texts that deliver the essence of Newton's natural philosophy to the general population (Yoshida 1988:109). Johan Lulofs (1711-1768), a Leiden University professor in astronomy, collected and edited John Keil's

works into a single volume and added annotations. Lulofs published it with the title *Inleidinge tot de waare Natuur-en Sterrekunde, of de Natuur-en Sterrekundige Lessen van den heer Johan Keill, M.D.* (it has been referred to as the *Collected Works of John Keil* 奇児全書 in Japan) in 1741. The Netherlands was the first European nation to accept Newtonian science, and it is said that faculty members of Leiden University were among the most active advocates of it (Yoshida 1987:30). Johan Lulofs also inherited the orthodox Newtonian science of the Netherlands (Yoshida 1988:111). The *Collected Works of John Keil* is generally understood as a prime textbook of orthodox Newtonian science of the Great Britain and the Netherlands.

Through the *Collected Works of John Keil*, Shizuki Tadao became the first Japanese to be introduced to orthodox Newtonian science. It appears highly likely that by 1782, when Shizuki was 23 years old, he had read the Dutch language version of *Collected Works of John Keil* (Yoshida 1988:112). Shizuki focused on the learning of Newtonian science, as well as translation, for the next 20 years until 1802, when he completed *Rekishō Shinsho*. Although *Kyūryokuhōron* and *Rekishō Shinsho* are considered to be mere "translations" of *Collected Works of John Keil*, Shizuki added in a number of citations from other books, new interpretations and modified theories. Glancing at the additions he made to the text, it is clear that Shizuki was more than a faithful translator of Newtonian science. He was a natural philosopher in his own right, who sought to convey his own vision of nature and humanity via Newtonian science. This aspect of his work, paired with the example of Choe Hangi of Korea, affirms the significance of research that compares the thoughts of these two men in the context of the East Asian intellectual tradition.

Characteristics of Newtonian Science

Science in eighteenth- and nineteenth-century Europe that, in particular, shared Newton's methodologies and worldview is generally referred to as Newtonian science. One of the most salient aspects of Newtonian science can be seen from Newton's quote, "I do not make hypotheses." Believing that there is no evidence that can induce or deduce the origin and mechanisms of action at a distance, Newton argued that all explanations of action at a distance are merely unscientific hypotheses. Newton wrote about his methodology as well as his worldview in the conclusion of his three-volume work, *Principia* (Newton 1687; Nakano 1977:651-52). He argued that, even

without understanding the origin or the physics of gravity, he was satisfied with merely being able to generalize the existence of gravity and explain the motions of the earth and the universe. However, the reason both Choe Hangi and Shizuki Tadao were dissatisfied with Newtonian science was precisely because it lacked an explanation of the origin and physics of gravity.

Newtonian science acknowledged the concept of supranatural and omnipotent God in order to establish the appropriateness and purpose of the existence of nature and man. Newton believed that the universe was created by God's divine will, and therefore all must obey his rule (Newton 1687; Nakano 1977:648). That understanding of God and nature was shared by his faithful disciple John Herschel, as well as Herschel's translators Alexander Wylie and Li Shanlan.

> The reason why I (Alexander Wylie) translated this book with Mr. Li (Li Shanlan) is to let more people know about the great abilities of God and make people humble for it. The right way to go is to continue to worship the heaven and repay its grace. (Wylie 1859:500b)

As can be seen in the abovementioned perspective on Newtonian science, the reason and purpose for all existence was given by God. The purpose of science, in that case, was to discover divine will in order to follow it.

The Newtonian perspective recognizes that God, the ruler of nature, sometimes intervenes in the workings of nature. Therefore, certain supernatural events were sometimes attributed to God. Newtonian scientist John Herschel once said,

> [Falling bodies] are therefore urged [to the earth's surface] by a force or effort, the direct or indirect result of a *consciousness* and a *will* existing *somewhere*, though beyond our power to trace, which force we term *gravity*. (Cannon 1961:227)

In his eyes, even the power of a spring came from the will of God. (Cannon 1961:227) However, such a perspective had no place in rationalist philosophy, which seeks to explain all phenomena in nature using natural causes and principles. In rationalism, all entities had to be intelligible (Hutchinson 1982:253).

Choe Hangi and Shizuki Tadao drew opposite conclusions on the question of a supranatural God. Although discontented with Newtonian science's unwillingness to explain the origin of gravity, Shizuki Tadao

nevertheless accepted Newtonian science's perspective on God by recognizing gravity's inconceivability. On the other hand, however, Choe Hangi did not recognize the existence of God and established his own philosophy and mechanics.

Choe Hangi and Newtonian Science

Gihak: Physical Substratum and Vital Activity

Choe Hangi's thoughts on Newtonian science was based on his *gihak* (氣學 "the study of *gi*"), developed even before his reading of John Herschel's work. *Gihak* is a system of thought that seeks to explain all phenomena of the universe using only the principle and mechanism of *gi*. Choe believed that calendrical astronomy and mathematics, and knowledge of *gi*, were the most important among the accomplishments of western science (Choe 1857:27). The knowledge of *gi* in western science, in particular, was the most important due to its role in clarifying the true nature of *gi*.

Choe Hangi believed that *gi* has two fundamental principles: "physical substratum 形質" and "vital activity 活動." He also believed that the two fundamental principles were proven by western science. To use the modern rendition of his words, "*gi* physically exists because of its physical substratum, and it can be intelligibly recognized." In addition, due to its constant movement, *gi* always gives off life energy and forces matter in the universe to move. The two fundamental principles of *gi*, as Choe Hangi defines them, were inferred from scientific theories and results of experiments in western science texts.

When he acquired the principle of "the physical substratum" of *qi*, *gi* (氣), the translated term of earth's atmosphere in the western texts, took on an important role. Western texts typically spoke of the atmosphere as something that has a number of physical properties, including having a role in determining temperature and humidity, creating pressure, refracting light, and conveying sound and smell. Choe Hangi thought that those characteristics were exactly those of *gi*. Based on that understanding of the nature of *gi*, Choe Hangi concluded that *gi* exists in the reality and could be noticed via experiments and observations.

Choe Hangi further extended the boundaries of *gi*'s existence from the atmosphere of the earth to the entire universe. After inferring from

facts found in western science texts, Choe Hangi concluded that *gi* exists everywhere in the universe. In *Bouxinnbian*(博物新編)(1855), for example, there were a number of elements that were translated in part as *gi*. In addition to already well-known electricity (電氣) and magnetism (磁氣), there was also oxygen (養氣) and hydrogen (軽氣) in the atmosphere. Furthermore, John Herschel's *Tantian* also spoke of other elements that could be seen from a telescope: atmospheres of individual planets, the photosphere, and star clusters. Choe Hangi realized that *gi* exists everywhere in the universe from such writings, and concluded that the nature of *gi* can be perceived via scientific experiments and observations.

As western science caused Choe to realize that *gi* exists everywhere in the universe and proved the nature of *gi*, Choe Hangi praised western science by saying, "nature of *gi* became revealed for the first time through experiments carried out by different instruments" (Choe 1860:98b). He also marveled at the potential of the breakthrough by saying, "It is as if the dark world is waiting for the sunrise" (Choe ca.1860:284a). By realizing that *gi* possessed a verifiable nature through western science, Choe Hangi discovered his bright road toward establishing a new system of thought, *gihak*.

"Vital activity (movement)," one of the two fundamental principles of *gi*, simultaneously signifies the endless vitality and motility of *gi*. Similar to the process of how Choe Hangi became sure of the physical substratum of *gi*, he also became sure of the movement of *gi* through western scientific knowledge. Choe claimed that "one can know of the movement of *gi* through the earth's rotation" (Choe 1860:98b). Choe had found out about the earth's rotation via books on western science. John Herschel's *Tantian*, in particular, contains an explanation of the earth's rotation.

Adding on his own inference to such writings, Choe concluded that the earth's rotation proves the activities of *gi*. As Choe was certain that *gi* exists everywhere in the universe, he believed that all celestial bodies are continuously moving because of such *gi*. Going further, Choe concluded that, as all celestial bodies are moving while being surrounded by *gi*, movements of celestial bodies tell the movements of *gi* and vice versa. He said, "Through the movements of *gi*, we know that all elements are already moving" (Choe 1860:68a). Through such inferences, Choe stated that the movements of *gi* can be realized by observing the rotation and revolution of the earth (Choe 1860:79b). As all elements are surrounded by circulating *gi*, Choe believed it was natural that the surrounded objects are spherical in shape. The fact that the earth was spherical was further evidence that *gi* was revolving around

the earth (Choe 1860:75d). Through such inferences from the movements of objects, Choe became sure of the movements of *gi*.

In addition to the earth's rotation and revolution, John Herschel's *Tantian* also contained writings on other celestial bodies such as the planets' rotations and revolutions, the movements of satellites and moons, and the sun's rotation. As was the case for the movements of the earth, the movements of celestial bodies provided further proof that the *gi* of the universe was on the move. As there was not a single celestial body that was at a stop, Choe concluded that all *gi* in the universe was continuously moving. Choe said, "The reason why there is not a single thing in the universe that isn't moving is because gigantic *gi* is at work" (Choe 1860:76a). For Choe, the universe was filled with continuously moving *gi* that gives off energy and movement to all elements of the universe.

Choe's fundamental concepts, "physical substratum" and "vital activity," can be read as equivalents to Descartes' "matter" and "motion." From this, surprising parallels can be observed between Choe Hangi and Descartes. Although there are partial differences, their natural philosophies are similar in the sense that they built up their thoughts by drawing inferences around two fundamental concepts. As will be described in great detail later, Choe Hangi's thought substitutes Descartes' "matter" with "*gi* with physical substratum" and "motion" with "gi's vital activity." In addition, the two men are similar in this sense that Choe Hangi seeks to explain the conveyance of strength and movement via "revolving gi" while Descartes did the same via the "vortices" of matter. The two men were also critical of the concept of gravity in Newtonian physics. They both considered it unreasonable that Newtonian physics fail to explain the origin and mechanism of gravity while positing gravity as a major premise of natural philosophy. While Choe Hangi never knew of Descartes' works, striking parallels came about as the two men sought to develop their respective philosophies based on the two (similar) fundamental concepts.

It is also important to note the difference between the two philosophies. In particular, they stand in conflict on the existence of God. While Descartes posits God as the first and only "unmoved mover," Choe Hangi sees the two principles of *gi* to be innate. According to Choe, nothing in the universe was created outside of nor can it be separated from *gi*. In this scheme, there was no place for the creator or the "unmoved mover." Considering this factor, Choe Hangi's *gihak* can be categorized as an atheistic and rational natural philosophy.

Discarding Newtonian Science and the Mechanics of Gi

Newtonian science is satisfied with mathematical descriptions without delving into the origin or physical mechanisms of forces (such as gravity). For the philosophy of *gi*, which seeks to explain all phenomena using the principles of *gi*, that tendency of Newtonian science is obviously an object of criticism. Choe Hangi responded to Herschel's text by saying that Herschel's work is a mere description of "what has already appeared."

As mentioned above, *gihak* aims to explain all natural phenomena using the basic principles of *gi*. Therefore, from the perspective of *gihak*, the origin and physical mechanisms of gravity must be explained prior to its description. That is the reason why Choe Hangi introduced *gi* here. Choe argues, "Force come from *gi* and immediately applies itself" (Choe 1834b: 30d). Choe Hangi translated the term "*ri,*" a word referring to the Newtonian concept of gravity, as "*gi*" while quoting materials from *Tantian* in his own book *Seonggi unhwa*, because of his belief that *gi* was involved as the origin and medium of gravitational action.

Choe Hangi defined gravity as "the force of earthly *qi* 地氣 pressing down" (Choe 1867:125b). As already mentioned, Choe Hangi believed that *gi* was the origin of gravity. Furthermore, Choe also contended that the physical mechanism of gravity is predicated upon the downward pressure of *gi*. From today's perspective, Choe Hangi's scheme of atmospheric pressure causing gravity is completely wrong. However, that argument is completely rational and justified from the perspective of Choe's *gihak*, as the accumulated *gi* in the atmosphere is supposedly exerting itself downward. From Choe's perspective, the downward force of *gi* was already proven by the Torricellian experiment outlined in western science books.

Taking a step further, Choe Hangi realized that all phenomena Newtonian physics describe can be explained by the downward force of *gi*. Choe argued, "When the *gi* around the earth rotates, it encloses the *gi* inside by building a shell. This is the reason why the earth turns out to be spherical in its shape" (Choe 1860:75d). He is arguing here that circulation of the *gi* surrounding the earth is creating pressure toward the center, and such pressure makes the earth spherical. Furthermore, that force causes objects that have moved away from the surface of the earth to move back down to the surface. From Choe's perspective, the inherent rotation of *gi* above the earth's surface causes downward force (pressure), and that downward force causes gravity. Everything could now be explained via the movements of *gi*. Choe became sure of his

theory on *gi* and gravity through such processes of deductive reasoning.

Choe became certain of his theory's general efficacy after applying it to several natural phenomena. For example, the spherical shape of the earth is a bit skewed, as the polar diameter is longer than the equatorial diameter. Newtonian science explained the discrepancy by arguing that the centrifugal force generated by the rotation of earth reduced the magnitude of the force of gravity around the equator. That discrepancy caused the region around the equator to become "swollen." Choe Hangi realized that, by substituting the force of gravity with his downward force of *gi*, he could likewise explain all physical phenomena. Choe believed that all phenomena already explained by Newtonian science, such as the rotation and revolution of the earth, the earth's spherical shape, and how people at an antipodal point can stand up straight and not be thrown off the earth, can be explained by his theory of *gi* (Choe 1860:78a). For Choe Hangi, fully convinced of the rationality and applicability of *gi* physics, descriptive Newtonian science, which had no explanation of the origin and physical mechanism of gravity, was merely "a conjectural opinion" (Choe 1867:179a).

On the other hand, Newton's gravity was universal, existing wherever mass exists. In order to replace Newtonian mechanics with the mechanics of *gi*, therefore, Choe Hangi had to present his ideas as being applicable in outer space as well. In order to present his theories as applicable in the celestial world, Choe Hangi invented the concepts of "*gi* globe" and "the forces of attraction and repulsion" based on the "*gi* globe theory."

As to the "*gi* globe" concept, Choe Hangi believed that all elements existing in the universe were surrounded by *gi*, and the movements of *gi* surrounding them brought out certain phenomena and caused us to recognize it. Inferring from this, Choe Hangi thought that it was evident that all matter in the universe is indeed surrounded by *gi* (Choe 1834a: 119c). As mentioned already, the earth itself also has an atmosphere surrounding it that causes a downward force toward the center. Choe Hangi concluded from such reasoning that all elements in the universe, including the earth itself, are always surrounded by the "*gi* globe."

Going further, Choe Hangi concluded, based on the knowledge of modern astronomy he gained from *Tantian*, that all celestial bodies in outer space must also have a "*gi* globe" of their own. *Tantian* contended that a thin atmosphere exists around the earth's moon, and that the planets and the sun are surrounded by clouds and a photosphere, respectively. Convinced that the clouds and photosphere must be *gi*, Choe Hangi argued

that they must be the "*gi* globe." (Choe 1867:103c). Choe believed that such discoveries, as explained in *Tantian*, effectively proved that the "*gi* globe" exist around all celestial bodies in the universe (Choe 1867:179c, 111a). Based on recent findings in western science as well as his own inferences, Choe Hangi believed that all things, from small objects in the earth to gigantic planets in outer space, are surrounded by the "*gi* globe."

On "the forces of attraction and repulsion," Choe argued that, "*gi* has two fundamental properties. One is attraction and combination, and the other is repulsion and refusal" (Choe 1866:455d). Choe also believed that "the forces of attraction and repulsion" were proven by the already-conducted experiments of western science. The phenomena of electricity and magnetism were typical examples (Choe 1866:468b). For instance, Choe Hangi believed that the phenomenon of lightning occurs when the clouds of "attraction" collided with clouds of "repulsion" (Choe 1866:468b). Choe even considered the conveyance of water in plants' capillaries to be based on the forces of "attraction" and "repulsion" (Choe 1867:120c). As can be seen from the examples mentioned above, Choe believed that "attraction" and "repulsion," the most essential properties of *gi*, occur wherever *gi* is active.

Choe Hangi was convinced that all elements in the universe have the "*gi* globe" around them. Then Choe became convinced that the "*gi* globe" activates the forces of "attraction" and "repulsion," the essential properties of *gi*. Choe Hangi could now create his own mechanics of *gi*. Substituting the forces of "attraction" and "repulsion" of the "*gi* globe" in place of the Newtonian concept of gravity, all mechanical actions explained by the Newtonian science could be explained by the mechanics of *gi*. For Choe Hangi, the origin of gravity that Newtonian science did not explain was explained by the fundamental properties of *gi*. All physical phenomena occurring between different elements were caused by applications of the forces of "attraction" and "repulsion."

Choe Hangi, as mentioned above, suggested the mechanism of downward force caused by the rotating *gi* explained gravity. Going a step further, Choe suggested a mechanism based on the forces of "attraction" and "repulsion" to explain gravitational actions in outer space. That was the *intersection* of "*gi* globes." The forces of "attraction" and "repulsion" activate whenever the "*gi* globes" of different celestial bodies pass by each other, causing various physical phenomena to occur. Choe Hangi called such intersections of "*gi* globes" *seopdong* (攝動). The term *seopdong* was first used for the English term "perturbation" in the translation of *Tantian*. The term

originally referred to the situation in which the gravity of a third celestial body was intruding upon and influencing the movements of two other celestial bodies. Although Choe was appropriating the term from *Tantian*, he used the term differently—for the application of the forces of "attraction" and "repulsion" during the "intersection" of the celestial bodies.

In order to build a system of celestial mechanics based on the forces of "attraction" and "repulsion" between different "*gi* globes," Choe supposed that the size of a "*gi* globe" is nearly infinite. According to Choe, the size of the "*gi* globe" of the earth goes beyond the orbit of the moon and goes as far as the sun (Choe 1867:122c-d). The "*gi* globes" of other celestial bodies are equally expansive, and there are a number of intersections for each "*gi* globe" (Choe 1867:179b). Choe argued, "The globe, repeatedly folded by outer globes, the farther the bigger, by reaching globes of stars in all directions, forms a whole mechanism and practices movements and changes" (Choe 1867:105a). Due to the nearly infinite reaches of the "*gi* globes," all celestial bodies are essentially interconnected.

By inserting the forces of "attraction" and "repulsion" in the structure of infinite intersections of "*gi* globes," all physical phenomena, as described by Newtonian physics, could be explained by the mechanics of *gi*. Even before this, Choe Hangi had already explained the tidal effect between the earth and the moon using the application of the "*gi* globe" concept (Choe 1867:120a). After that, based on the knowledge of celestial mechanics he gained from reading *Tantian*, he became certain of the existence of "*gi* globes" as well as the forces of "attraction" and "repulsion" that the "*gi* globes" drive.

Choe Hangi argued, "As a result of the attraction by one body and repulsion by the other, orbital rotation is achieved" (Choe 1867:120b). "Were it not for *gi* globes, on what ground could the second and third bodies at distance attain attractive and repulsive action?" (Choe 1867:179d). As can be seen, Choe Hangi was certain that the orbital motions of all celestial bodies could be fully explained by the mechanics of *gi*. At that point, Newtonian science, which does not explain the origin and physical mechanisms of gravity, became an incomplete theory that lacks a full understanding of the fundamental properties of *gi*. In the end, Choe Hangi discarded Newtonian science altogether.

> If there is a discrepancy between two theories (*gi* globe theory and Newtonian celestial mechanics), I would rather abandon the values of tangential and normal perturbation than give up this real trace of *gi* globe. (Choe 1867:181-c-d)

> One who seeks heavenly live astronomy enters its study through the *gi* globe while others who seek earthly dead astronomy accept perturbation and use tangential forces. (Choe 1867:199a-b)

As can be seen from the quotes, Choe Hangi labeled the usage of the concepts such as "tangential force" or "normal force" to be "dead astronomy." For Choe, Newtonian science was something that only describes "what had already appeared" without ever delving into the essential features of *gi*. On the other hand, however, his own theory that was based on a full understanding of *gi*, the ultimate source of the universe, was a "live astronomy." Although Choe recognized the sophistication of mathematical descriptions of Newtonian mechanics, he nevertheless firmly believed that such a technique could not come before the mechanics of *gi*. That was the reason why Choe thought that elements of Newtonian mechanics that do not agree with his theory could be discarded.

Dynamics to Ethics

The purpose of scientific study in Newtonian science was to read God's divine will from natural phenomena and obey it. In Newtonian science, God was the reason behind the existence of man and nature. The appropriateness of man and nature also comes from God the creator. On the other hand, the purpose of Choe Hangi's *gihak* is to find the ultimate principles of *gi* and follow and participate in the movement of *gi* in the universe. In addition, as the *gihak* does not recognize the concept of supranatural God, the appropriateness and purpose of man's existence also does not come from God. As all things in the universe are created and changed by the movements of *gi*, the purpose also comes from the *gi*. "Successive following" is the ethical concept that Choe Hangi suggested to deduce the purpose of the existence of man and nature from *gi*.

As already mentioned, according to Choe Hangi's *gihak*, everything that exists is surrounded by a "*gi* globe." One "*gi* globe" intersects with the others, creating an infinite chain of intersections in the universe. Therefore, everything that exists exchanges influence with everything else in existence. As do the celestial bodies, each and every individual also interacts with others in a reciprocal manner through the intersections of their "*gi* globes." Human beings also interact with all celestial bodies in the universe, including the earth itself. Therefore, everything in existence in the universe participates in

the movement of the universe. There is not a single entity in the universe that stands on its own without interacting with other something else in existence.

Just as the interaction between the earth and the moon is interconnected with larger movements in the solar system, all movements in the universe are interconnected with larger movements that occur in the universe. Satellites are interconnected with the planets, the planets are interconnected with the solar systems, and the solar systems are interconnected with the movements of the entire universe. Likewise, movements of individual people are interconnected with the small groups they belongs to; the movements of small groups are interconnected with the movements of large groups; the movements of large groups are interconnected with the movements of states; and the movements of states are interconnected with the movements of the world. The movements of the world are interconnected with the movements of the earth, and the movements of the earth are interconnected with the movements of the solar system. Choe Hangi therefore believed that everything in existence in the universe is interconnected with existent smaller mechanical structures as well as larger mechanical structures.

> Choe Hangi deduced the concept of "successive following" from the hierarchy of the mechanical structure of motions in the universe. Choe Hangi said the following:
>
> Saturn successively follows the movement and change of the star woods [星林, a group of stars and nebulae], Jupiter does of Saturn, Mars does of Jupiter, the sun-Venus-Mercury do of Mars, the Earth and the moon do of the sun-Venus-Mercury, human beings and things do of the Earth and the moon. (Choe 1868:370d-371a)

As can be seen from the quote, everything in existence in the universe "succeeds" and "follows" according to their place in the hierarchical structure of movements. That is why it is most upright and ethical to "succeed" and "follow" according to one's place within the mechanical structure. Therefore, attempts at crossing or leaving the structure are immoral. As human beings are part of the infinite chain of "*gi* globe" interconnections, the only right and moral thing to do is to abide by the structural order. Choe Hangi argued the moral duty of humanity as the following:

> If the five moral imperatives (五倫) between ruler and minister, father and son, husband and wife, old and young, and friends work well, celestial bodies will interact and successively follow. If humanity, righteousness,

> propriety and wisdom (仁義禮智) are not based on heaven, nonessentials are carried out. If moral training, home management, governing a nation and securing the world (修齊治平) are not based on the heavenly assignment, it leads to ruin and chaos. (Choe 1867:111d)

Here he is arguing that the principles of ethics and morality can be ascertained by learning about the physical mechanisms of "*gi* globe" interactions and following them. Choe Hangi deduced the grounds of human morality and ethics via the movements of "*gi* globes" and the mechanics of *gi*, without ever having to refer to a supranatural God.

As shown above, Choe Hangi deduced the two principles of *gi* from the scientific theories and facts of western science. Convinced that force comes from *gi*, Choe criticized Newtonian science for not explaining the origin of gravity and the physical mechanism of gravitational action. Choe Hangi detected that Newtonian science only focuses on mathematical description of phenomena. Choe Hangi's description of Newtonian science, the writing of "what has already appeared," exemplifies Choe's perception of Newtonian science. Choe's *gihak* did not recognize the supranatural God on which Newtonian science was premised. Rebuffing any notion of supernaturalism, *gihak* sought to explain all phenomena of the universe using the single concept of *gi* and its movements. By presenting the mechanism of the forces of "attraction" and "repulsion" via the intersections of "*gi* globes," Choe Hangi fully substituted Newtonian mechanics with mechanics of his own. Reaching further, Choe Hangi believed that abiding by the hierarchical structure of the mechanical universe was the most moral and ethical thing to do. On the basis that Choe Hangi sought to explain all natural phenomena from the single concept of *gi* and deduced the grounds of morality from the mechanics of *gi*, his thought could be called a "*gi*-centered atheistic and rational natural philosophy."

Shizuki Tadao and Newtonian Science

The Eye to See Newtonian Science: Gi

Unlike Choe Hangi, Shizuki Tadao did not have a philosophy of his own when he first learned about Newtonian science. However, Shizuki was nevertheless influenced by the universalism of *gi*, a perspective shared in premodern East Asia. The *gi* cosmology was widespread in East Asia since ancient times,

in which *gi* was recognized as a fundamental element of the universe. In addition, a number of translated western science books used the term in translating words such as atmosphere, electricity and magnetism. Therefore, for premodern East Asian intellectuals who shared the cosmology of *gi* and read western science books, immaterial and fluid elements as described in western science books were read as *gi*. As already mentioned, Choe Hangi, for instance, identified the sun's photosphere as *gi*. Shizuki Tadao was similar to Choe in this aspect. Shizuki considered or translated the immaterial and fluid elements discussed in the *Collected Works of John Keil* as *gi*.

Shizuki Tadao read a number of translated western science books such as *Lixiang kaocheng* (Compendium of Calendrical Science and Astronomy, 1723) and *Lingtai yixiangzhi* (Records of Astronomical Instruments of the Imperial Observatory, 1673), and was well aware of the physical characteristics of immaterial matter such as air, electricity and magnetism. Shizuki was also aware of the *gi*-centered cosmology of You Yi (遊藝, 1614-1684) and his *Tianjing huowen* (天経或問), which reinterpreted western science using the traditional East Asian concept of *gi*. Shizuki Tadao's declaration in his *Rekishō Shinsho*, "the universe is a unified *gi*" (Shizuki 1802:69), shows a typical perspective of a premodern East Asian intellectual.

Shizuki Tadao, in particular, used the *gi* concept in interpreting Newtonian theories on matter and particles (Yoshida 1972:391). Newtonian science, as was believed by John Keil, held that all matter was made of particles (*particula*). If a certain type of matter was continuously divided, it turns into a particle, which does not lose its physical properties. Shizuki Tadao, in his *Rekishō Shinsho*, translated the particle as "*bunshi* 分子" (molecule). Shizuki paid particular attention to the fact that matter does not lose its fundamental properties with division. It seems that this reminded Shizuki of *gi*, the ultimate substance in the East Asian natural philosophy, which retained its fundamental properties while it was gathered and scattered. He combined Newtonian theories of matter with those of *gi*. Shizuki argued that *gi* forms if indivisible particles gather together. As already proposed by the theories of *gi*, it was obvious to Shizuki that a gathering of *gi* turns into material. Shizuki Tadao argued that "*gi* is made of a gathering of quality" (質) (Shizuki 1802:72), and quality here refers to the fundamental properties of a kind of matter that a particle retains. He also declared that "a gathering of soil quality (土質) is soil *gi* (土氣), and a gathering of soil *gi* is the earth," and one can observe the structure of his logic: particle-*gi*-material. As a modern researcher proposed, it can be said that Shizuki Tadao fused the

particle theory of Newtonian science and the traditional theory of *gi* into "the relativity of *gi* and quality" (Yoshida 1976:30-31).

Due to his usage of *gi* theory in interpreting Newtonian concepts, Shizuki pursued his research from a different perspective and came up with results which differed from Newtonian concepts in two ways. For example, although Newtonian science argues that space is empty, Shizuki Tadao disagreed and argued that it is filled with *gi*. As mentioned before, Newtonian science did not attempt to discover the origin of gravity. Shizuki Tadao, however, sought to find an answer and guessed that gravity originated from *gi* and was conveyed by it.

Although Newtonian science proposes a vacuum space where elemental particles exist, Shizuki Tadao's reinterpretation of the theories and facts of Newtonian science led him to believe that a vacuum cannot exist due to the omnipresence of *gi* (Yoshida 1972:388). Among the theories of Newtonian science, particularly important to Shizuki's reinterpretation was the "imponderable fluid" theory. Eighteenth century Newtonian science supposed that an imponderable fluid was involved in phenomena such as electricity, magnetism, light and heat. Imponderable fluid was believed to be so sparse that it would enter the spaces between the particles of a material object. Shizuki Tadao considered the imponderable fluid, as described in John Keil's work, to be *gi*. Shizuki translated John Keil's "imponderable fluid" into "*hōki*" (放氣, the released *gi*) mindful of its supposed ability to go into any kind of material objects and cause effects (Yoshida 1976:31).

As can be seen in the translated term *hōki* (the released *gi*), Shizuki Tadao equated the imponderable fluid with *gi* released out of elements. In addition, this imponderable fluid, thought of as a fluid, would not lose or gain mass despite its movements in and out of other material objects. That nature was also seen as similar to that of *gi*. Shizuki Tadao posited that, as the universe was filled with phenomena involving electricity, magnetism, heat and light via imponderable fluid, *gi* was therefore omnipresent. According to this scheme, a vacuum without *gi* was impossible. Shizuki stated, "Anywhere where light reaches or *gi* comes across is not a vacuum" (Shizuki 1802:160).

Unfathomable Force, Gravity

As mentioned above, Shizuki Tadao believed, through his interpretation of imponderable fluid, that the universe was filled with *gi* and *gi* was therefore the cause of all actions and phenomena. By dislodging the concept of a vacuum, Shizuki Tadao sought the origin and physical mechanism of

gravitational action, and he found his answer in *gi*.

First, Shizuki Tadao concluded that all forces, including macro-forces like gravity (重力) as well as micro-forces like attraction (引力) between particles, are identical. He stated, "Although there are two terminologies, attraction and gravity, they are from a single root. Ones that fall to the ground are called gravity, and ones that pull particles together are called attraction" (Shizuki 1802:72). As mentioned above, Shizuki Tadao believed that all matter in nature is in a continuum via partition and accumulation (particile-*gi*-material). Therefore, from his perspective, both macro-forces like gravity and micro-forces like attraction between particles have the same origin and function.

Based on that inference, Shizuku Tadao concluded, "As the particles of a matter are *gi*, attraction between particles comes from *gi*" (Shizuki 1802:149). "That (gravity) is actually a mutual pulling between the *gi* of all material objects and *gi* of the earth" (Shizuki 1802:70). By interpreting the theories of matter in Newtonian science as *gi*, Shizuki Tadao ended up believing that all forces existent in the universe originate from *gi*.

In addition, Shizuki Tadao sought to explain the physical mechanism of gravitational action using the *gi* concept. John Keil explained electro-magnetic attraction with the concept of imponderable fluid. I think this led Shizuki to invent his own theory of gravity (Yoshida 1972:393). John Keil contended that imponderable fluid comes out of material objects and reaches out to other objects at a distance. Keil believed that such a mechanism was behind phenomena such as amber pulling in dust or a magnet pulling in iron filings. However, Shizuki sought to apply this idea to gravitational action as well. From Shizuki's perspective, if imponderable fluid equates to *gi* and electro-magnetic attraction is acting between *gi*, then gravitational action would also have to do with *gi*. Shizuki claimed, "This (the theory on electro-magnetic attraction) was in his (John Keil's) physics book. Thinking of it now, however, the weight would be as same as the electro-magnetic attraction" (Shizuki 1784:50). The term "weight" (重), as used here, refers to the gravity which is acting between weighty bodies. It was Shizuki's estimation that gravity would have the identical mechanism as electric magnetism.

Although Shizuki Tadao did not continuously endeavor to establish an organized theory of gravitational action, he even once guessed that the mechanism behind the tidal forces between the earth and moon was a *gi*-based mechanism. He stated, "The surface of the earth receives a bit less *gi* from the moon. But the moon's *gi* touches upon all areas of the earth's circumference. That is why the moon's *gi* and the seawater of the earth pull each other. There

are therefore high tides of seawater in the four corners of the earth" (Shizuki 1784:50). As can be seen, this quote speaks of the following process: the moon's *gi* reaches the earth, pulls the earth's seawater, and produces the tides.

Shizuki Tadao's theory on gravity is reminiscent of how Choe Hangi used the *gi* concept to explain the workings of gravity. Both men applied the traditional East Asian concept of *gi* to explain the origin and mechanism of gravity, which was left out of Newtonian science. Newton argued that theories on the origin and mechanism of gravity are all hypothetical. The two men, however, fully convinced of the omnipresence of *gi* in the universe, could not accept the Newtonian silence on the matter. Mere mathematical descriptions were not enough for either Choe Hangi or Shizuki Tadao. As they were convinced of the omnipresence of and the movement of *gi* in the universe, they sought to explain origin and mechanism of gravity using the concept of *gi*.

However, Shizuki Tadao did not go beyond applying the theory of *gi* to the origin and mechanism of gravitational action. Although discontented with the silence of Newtonian mechanics on the subject, he nevertheless accepted the Newtonian perspective without attempting to come up with an alternative mechanical theory. While Choe Hangi, in this sense, was a philosopher who sought to establish his own independent philosophy, Shizuki Tadao was more of a student of Newtonian science and its worldview than an independent philosopher. Shizuki Tadao recognized that, following the Newtonian perspective, the origin and mechanism of gravitational action is something human intellect could not discover.

> Gravity originated from the unknown, but it acts on everything in the universe. (Shizuki 1802:69)
>
> The reason why gravity is gravity is mysterious and cannot be measured. (Shizuki 1802:162)

God's Will and Human Ethics

Principles of the natural world and standards of human ethics cannot be separated in traditional Confucian philosophy. Choe Hangi's case, as already mentioned, exemplifies this perspective. He established the standard of human ethics using the existence and movements of *gi*. On the other hand, Shizuki Tadao as mentioned above, accepted the perspective of Newtonian science,

and declared that humanity cannot know the origin and mechanism of gravity. This means that Shizuki relinquished the traditional Confucian perspective of establishing the standard of human ethics based on the principles of the natural world. Shizuki Tadao had to find humanity's moral standards through the supranatural God, the supposed founder of the universe.

Shizuki contended that the ultimate logic behind the natural world cannot be known to man.

> The world is filled with things that people cannot know. Who made the universe? Who made *gi*, who made heaven and earth, and who made principles that move all things constantly? Who made differences in gravitational power? (…) Who gave human beings consciousness and spirit? Who made them see, hear, speak, act, think, and distinguish, and search for the truth? We cannot know what to search and even why to search. (Shizuki 1802:162)

As mentioned in the quote, humanity cannot know the ultimate principles behind nature, and therefore cannot deduce the standard of human ethics from the principles of nature. That is why the seemingly perfect order of nature and its functions were attributed to the works of the creator. As Shizuki Tadao, like Newtonian scientists, accepted that the ultimate principles behind the nature cannot be known to the human intellect, he had no choice but to accept the concept of an omnipotent God the creator.

From acknowledging the omniscient God to setting up the standard of human ethics, Shizuki seems to have followed the logical path of Newtonian scientists. Shizuki Tadao praised the great knowledge of God the creator. Such praise is identical to that of Newtonian scientists. He said the following:

> What a miraculous world it is. It is the most superb sight. If such great harmony was not founded by the omniscient (God), how could this even be possible? (Shizuki 1802:41)

Shizuki Tadao, then, concluded that the standard of human ethics is provided by God, and what human beings have to do is discover the divine will of the creator and act according to it. Shizuki said the following:

> Because the incomprehensible God of human beings exists everywhere, we have to seek the truth (of human beings) focusing on the mind. Because the incomprehensible God of the universe is omnipresent, we have to seek the truth (of the universe) focusing on the sun. (…) We

> should cleanse our bodies, obey and respect our parents, serve the king, and combine our minds with the mind of the sun in following the orders of the heaven. That is the reason why we revere the highest being (God) in the universe. (Shizuki 1802:163)

As can be seen from the sentence "the reason why we revere the highest being in the universe," Shizuki Tadao believed in God as the highest being. He also believed that it was a duty for human beings to discover God's divine will in nature and follow it. We can see here that Shizuki Tadao accepted the fundamental perspective of Newtonian science, the concept of inconceivable gravity and the supranatural God.

For Shizuki Tadao, as described, the morality of mankind was granted by the supranatural God instead of the principles of nature. Choe Hangi, on the other hand, did not recognize the supranatural God. For Choe, humanity's ethics can only be deduced from the principles of *gi*. Choe Hangi and Shizuki Tadao suggested completely opposite answers to the question of the existence of a supranatural God.

Conclusion

As explained above, these two intellectuals of premodern East Asia displayed both similarities and differences in their responses to Newtonian science. First, Choe Hangi and Shizuki Tadao were similar because they interpreted Newtonian science using the traditional East Asian concept of *gi*. The theories of *gi* served as the common intellectual foundation for premodern East Asian intellectuals. Seeing Newtonian science through the *gi* paradigm, it appeared irrational that Newtonian science did not explain the origin and mechanism of gravitational action. It was obvious to premodern East Asian intellectuals that *gi* constituted the origin and physical mechanism of gravitational action. That is the reason why both Choe Hangi and Shizuki Tadao problematized Newtonian science and sought to explain gravitational action using the *gi* concept.

Despite the common foundation, however, the natural philosophies of Choe Hangi and Shizuki Tadao differed significantly. Choe Hangi established his own natural philosophy based on the theory of *gi*, creating an independent mechanics of *gi* from the Newtonian one, and in the end, he discarded Newtonian mechanics. Not only did Choe Hangi not recognize the supranatural God, he explained all natural phenomena using the theory and mechanics of *gi*. Choe Hangi even deduced human ethics from the

movements of gi. In short, *gi* was the only principle needed to explain the existence and significance of nature in Choe Hangi's natural philosophy.

On the other hand, Shizuki Tadao sought to discover the origin and mechanism of gravitational action by applying the concept of *gi*. However, Shizuki did not exert himself to invent an independent mechanics and philosophy of *gi* with the amount of dedication Choe Hangi had. In the end, Shizuki Tadao accepted the perspective of Newtonian science admitting that the origin of gravity cannot be understood. At that point, Shizuki could no longer deduce human ethics from the principles of nature, and had to rely on the concept of a creator-God. By failing to establish an independent natural philosophy of his own, Shizuki Tadao, despite his usage of *gi* philosophy in interpreting Newtonian science, ended up accepting Newtonian science as well as its God.

If one places Choe Hangi, a natural philosopher of *gi*, on one end of a pole and place Newtonian scientists such as John Herschel and John Keil on the other end, the place occupied by Shizuki Tadao would be somewhere in the middle. In terms of the level of understanding of Western scientific theory and facts, Shizuki Tadao is more of a modern scientist than Choe Hangi. However, if one reviews the scholarship of the two men in accordance with the standard of universalization and systemification of *gi* philosophy, Choe Hangi comes closer to being a full natural philosopher. The differences between the two men, a Korean natural philosopher and a Japanese student of modern Western science, perhaps alludes to differences between Korea and Japan in their speed and direction toward westernization and modernization.

It is equally important to note that the Newtonian science Choe Hangi and Shizuki Tadao understood was not the Newtonian science as it was in the West. Western science in premodern East Asia constituted context-dependent knowledge which East Asian intellectuals interpreted in their own cultural and historical context, and new thoughts grew out of that fusion of knowledge.

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Abstract

This article observes how Newtonian science was interpreted by two intellectuals from Korea and Japan who encountered it for the first time in their respective countries. In their responses, Korea's Choe Hangi and Japan's Shizuki Tadao displayed both similarities and differences. First, they are similar because they interpreted Newtonian science using traditional East Asian *gi* theory. Universalism and materialism of *gi* functioned as a common intellectual basis for premodern intellectuals of East Asia.

Despite their common *gi*-based foundation, their thoughts on natural philosophy, as expressed through their interpretations of Newtonian science, display differences. Choe Hangi built a *gi* philosophy of his own using only *gi* theory. Devising a *gi* mechanism, Choe ultimately discarded Newtonian physics. In his *gihak*, the supranatural God was not recognized and all phenomena of nature were explained using only his mechanics of *gi*.

Shizuki Tadao also attempted to interpret Newtonian science by applying the theory of *gi*. He denied the concept of a vacuum, and sought to explain the source and mechanism of gravity through *gi*. He did not, however, exhaustively pursue the theory and philosophy of *gi* as did Choe Hangi. Accepting the perspective of Newtonian science, Shizuki Tadao recognized the origin of gravity as unknowable. Then, Shizuki could not deduce the standard of morals and ethics of the humanity from the principles of nature and had to acknowledge the supranatural God as the creator and ruler of nature.

The Newtonian science these two East Asian intellectuals understood was not the Newtonian science of the West. In premodern East Asia, Newtonian science was a context dependent knowledge, meaning its place was dependent upon specific historical and cultural contexts.

Keywords: Newtonian science, *gi,* gravity, supranatural god, imponderable fluid

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