

An Exploration of Complexity Science and Classical Chinese Thought: The Potential for Ancient Ideas to Enrich the Modern Study of Complex Systems

Jonathan Y. H. Sim¹, Jan W. Vasbinder²

¹ National University of Singapore (NUS)

² Para Limes, Nanyang Technological University

E-mail: jyhsim@nus.edu.sg, jan.w.vasbinder@paralimes.org

Introduction

Complexity Science is a relatively new field in the sciences (about 30 years old). Much progress has been made, and scientists have been able to develop many sophisticated concepts and methods for understanding complex systems and their emergent phenomena.

Yet, despite these advances, there are still many aspects of complex systems that remain a mystery. Though Complexity Science is able to capture certain phenomena using concepts such as “self-organisation”, “emergence”, “co-evolution”, and “path-dependence”, these concepts only scratch the surface of the phenomena, and they fail to explain the dynamics of how these phenomena come to be. Deborah Gordon¹, a renowned scientist, summarises this problem very succinctly:

“Recently, ideas about complexity, self-organisation, and emergence – when the whole is greater than the sum of its parts – have come into fashion as alternatives for metaphors of control. But such explanations offer only smoke and mirrors, functioning merely to provide names for what we can’t explain; they elicit for me the same dissatisfaction I feel when a physicist says that a particle’s behaviour is caused by the equivalence of two terms in an equation. Perhaps there can be a general theory of complex systems, but it is clear we don’t have one yet. A better route to understanding the dynamics of apparently self-organising systems is to focus on the details of specific systems. This will reveal whether there are general laws... The hope that general principles will explain the regulation of all the diverse complex dynamical systems that we find in nature can lead to ignoring anything that doesn’t fit a pre-existing model. When we learn more about the specifics of such systems, we will see where analogies between them are useful and where they break down.”²

¹ Deborah Gordon is a Professor of Biology at Stanford University. More information about her and her works can be found on her website: <http://web.stanford.edu/~dmgordon/>

² Melanie Mitchell, *Complexity: A Guided Tour* (New York: Oxford University Press, 2009), pp.293-294

This is where we turn to classical Chinese thought, with the hope that ancient wisdom may add content to, and broaden our concepts of complex systems. In this paper, we will explore some ideas from classical Chinese philosophy so as to illustrate the convergence of ideas between the classical thinkers and concepts that have been and are being developed in Complexity Science.

This paper is not meant to be a philosophical discussion, but an exposition and exploration of ideas within early Chinese thinking, meant to provoke further thoughts and ideas, that we hope may lead to fruitful and enriching insights. We believe that ideas from classical Chinese thought can help to enrich existing concepts in Complexity Science, and so enrich and broaden our perception and understanding with new ideas and insights to the study of complex systems.

We do not imply that either classical Chinese thought or modern Western science is superior to the other. Rather, we think that the two totally different traditions of thinking have led to different approaches for problems that are common to both worlds. These approaches have merit and virtue in their own culture and context but may very well be of significant value to each other.

The ancient Chinese did not have the concepts for understanding complex systems as we do today, but they were intimately familiar with complexity and had ways and means to understand and prescribe solutions for dealing with complex systems in everyday life, be it on the individual level of health, or with harmony on the societal level.

A compelling reason for the study of classical Chinese thought in relation to complexity lies in the fact that the ancient Chinese world started on intellectual premises that were fundamentally different from the West. Both traditions, conditioned by very different historical and cultural starting points, started out asking very different questions that eventually shaped their entire culture and worldview.³ The ancient Western thinkers were concerned primarily with “What” questions: What is the world made of? What is the good life? What is justice? This eventually led to an intellectual tradition that gave primacy to being, to end-states, to the idea that there are eternal, universal and unchanging principles to be acquired through the process of abstraction and reduction. The ancient Chinese thinkers, on the other hand, were concerned with “How” questions: How do we restore order? How do we restore harmony? This led to an intellectual tradition that gave primacy to becoming, on processes rather than on end-states, and on the importance of context to give meaning to things (as opposed to abstracting away the context to arrive at an eternal and unchanging truth or principle).

It is interesting to note that when the Santa Fe Institute started some 30 years ago, one motivating factor was that its founders realized that science as they knew it could, by rigorous analysis, get to the smallest of particles and the most fundamental of laws, but it did not offer a clue on how to synthesize those particles and laws into the world as we know it. In his iconic article, *More is Different*, P.W. Anderson states:

“The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact, the more the elementary particle physicists tell us about the nature of fundamental laws, the less relevance they seem to have to the very real problems of the rest of science, much less to those of society.”⁴

³ A. C. Graham, *Disputers of the Tao: philosophical argument in ancient China* (La Salle: Open Court, 1989), 3—4.

⁴ P. W. Anderson, “More Is Different”, *Science*, New Series, Vol. 177, No. 4047 (Aug. 4, 1972), 393—396.

The development of complexity science, which was strongly catalysed by the multidisciplinary community of the Santa Fe Institute, constituted a fundamentally new way to understand our world. Instead of looking at objects of study top-down in a reductionist manner as had been done for four centuries, Complexity Science seeks to look at its objects of study from the bottom up, seeing them as systems of interacting elements that form, change, and evolve over time. Process and context (as opposed to abstractions and reductionism) are at the core of Complexity Science. And it is here that it potentially meets the classical Chinese tradition. Hence we think that classical Chinese thought may have something to offer to enrich our understanding of Complexity Science.

One concern readers may have with this endeavour is that we might be wishing too hard for classical Chinese thought to give us insights into complexity, to the extent that we begin to project our own ideas of complexity into our reading and understanding of Chinese philosophy. This is a valid concern, and we have been careful to ensure that we avoid this. Nonetheless, it is clear from the classical Chinese texts that many ideas and issues they discuss do indeed deal with complex systems, and more often than not, with what we today refer to as complex adaptive systems.

Here are two examples of complex adaptive systems discussed in the classical texts:

In the Spring and Autumn Annals, the ancient scholar-minister, Yi Yin, advised the king about social harmony using the illustration of cooking broth:

“Harmony is like making soup. One needs water, fire, vinegar, sauce, salt, and plum in order to cook fish and meat. One needs to cook them with firewood. The cook has to harmonise the ingredients together in order to balance the taste. He needs to compensate for deficiencies and to reduce excessiveness.”⁵

The contents of the pot is a complex adaptive system, where the experience of harmony is an emergent phenomenon when the individual flavours have been adjusted to the right intensity. With the addition of a new ingredient to the system, the flavour of the soup of the other ingredients will change. If a certain flavour is too strong, it is not enough just to dilute the broth, as doing so would weaken the intensity of all the other flavours. Yi Yin goes on to describe how other ingredients must be added in order to balance out the meat’s strong flavour. In a similar way, social harmony requires a chef-like understanding of society, that every new change will affect everyone in one way or another. And that social harmony cannot be effected linearly through a series of actions, but by means of balancing certain strong “ingredients” with other “ingredients.”⁶

Similarly, the classical text on traditional Chinese medicine, the Huang Di Nei Jing Shuwen, presents a picture of the human body as a complex adaptive system, “a system of tangible organs and secondary body parts closely related to each other.”⁷ In a healthy body, the organs are able regulate the flow of qi (氣 vital energy) as it enters the body, and as it circulates within the body. A disease in the major organs would affect the subordinate parts, and vice versa, the diseased subordinate part will affect the

⁵ Chunqiu Zuo Zhuan Zhu 春秋左傳注 [Commentary on the Spring and Autumn Annals and Zuo Transmissions], ed. Yang Bojun 楊伯峻 (Gaoxiong: Fuwen tushu chubanshe, 1991), “Shaogong 昭公”, “Year 20”, p.1419. Translation by Jonathan Sim.

⁶ In terms of Complexity Science, the actions of the “cook” are “interventions” in a complex adaptive system. This cook has learnt from experience (by studying the consequences of many small interventions) how to predict or control the taste of the soup, thereby indicating that there are ways to influence the behavior of complex adaptive system in a predictable way.

⁷ Paul U. Unschuld, *Huang Di Nei Jing Su Wen: Nature, Knowledge Imagery in an Ancient Chinese Medical Text* (Berkeley: University of California Press, 2003). p.143

major organ if left untreated for too long. This will affect the flow of qi within the body, thus affecting the other organs and subordinate body parts.

Moreover, since “the health of a human organism depended on balanced exposure to the various climatic factors, such as wind, cold, and heat, and on unimpeded and proper flow of these and other so-called qi through vessels in the body,”⁸ disease may also arise due to excesses in the environment. For example, if the environment is too hot, too cold, too dry, too moist, qi flowing through the body will be irregular, and this in turn will affect the organs and their subordinate body parts. When the balance of health is disrupted, the Chinese physician cannot simply treat the afflicted part directly. Rather, he must be aware of the relationships between the organs and subordinate parts, and indirectly treat the afflicted part (through other organs or body parts linked to it), to slowly restore the balance in the system.

In the following five sections we intend to illustrate why we think Chinese thinking may enrich the study of complex systems.

At this point, we should note that just as there are (still) many different ways to describe complexity and its science, there are many different philosophical schools in classical China. While it is useful to simply refer to these various schools and ideas as “Chinese philosophy” for our purposes of exploration here, we may lose out on the rich nuances between them. Where we think it is useful to our explorations we will point out some of these nuances.

1. Context, Path Dependency, and Dao

While complex systems tend to behave in unpredictable ways, their behaviour is not completely random or chaotic. It is guided, or constrained, by their context: be it history or other factors. This is known as path dependence. The concept implies that a complex system can only behave in certain ways depending on its context, including its history and where it currently is.⁹ Each limiting factor within a context may constrain a system or individual agents in an insignificant way. But taken as a whole, all the limiting factors will constrain the entire system to behave or travel down a certain path of development (or at least one of a few possible paths) from which it cannot deviate much. Thus it is said to be path dependent.

There is a similar concept in classical Chinese philosophy: Dao (道), which can be translated as: (a noun) “a way,” “The Way,” or “ways” ; (a verb) “to guide.” Historically, Dao was an important technical concept to the classical Chinese thinkers as they were looking for The Way to restore order and harmony in a period of conflict and chaos (it was only much later that Dao acquired metaphysical significance). Nonetheless, the debate about the right Dao for restoring order, led to philosophical discussions about Dao itself.¹⁰ The first passage of the Daodejing states: “The Dao (way) that can be paved is not the eternal constant Dao. Names that can be named is not the eternal constant name.”¹¹

⁸ *Ibid.*, p.96

⁹ Path dependence in its loosest sense means that current and future states, actions, or decisions depend upon the path of previous states, actions, or decisions. See e.g. Scott E. Page, (June 20, 2005) *An essay on the existence and causes of path dependence*.

¹⁰ For more information, please refer to A. C. Graham, *Disputers of the Tao: philosophical argument in ancient China* (La Salle: Open Court, 1989).

¹¹ Translated by Jonathan Sim. *Daodejing*, 1: “道可道，非常道。名可名，非常名。”

There are hundreds of translations of the Daodejing available. As translations can never fully capture the meaning of the original text, here are two other translations to give you a sense of what the text is saying: “As to a Dao (way), if it can be specified as a Dao it is not a permanent

This cryptic passage means to say: Words (or names, as they are referred to in classical Chinese) not only describe, they also prescribe. Words do not just tell me facts about the world. Their very description also guides a certain course of action. If I were to hand an object over to you and name it a “gift,” the very description of the object as a gift would immediately guide you to behave and respond in a certain way. Had I named the object as a “purchase” or a “loan,” your behaviour towards it would be very different.

One more thing about words is the need for a context to understand their meaning. This problem may not be obvious in Western languages, but it is a big issue in classical Chinese and continues to be an issue in the modern Chinese language. For example, if I were to say “dao,” which word am I referring to? There are so many words that share the same sound. And even if you knew which Chinese word I am referring to, the same word will have several meanings. So which specific meaning did I intend? Context is thus essential in figuring out not only the precise word but also the precise intended meaning of the word. Moreover, context is also necessary for filling in a lot of the background information to make sense of the sentence. A string of words in one context will give rise to one dao, one guiding way, whereas the same string of words in another context may give rise to yet another dao, another guiding way. For example, “Of course you can,” may be interpreted in one context literally to mean that you have the permission to go ahead, but it may also be interpreted in another context sarcastically to mean that you should not do it.

Thus far, what we have said is not new to Complexity Science. Context of the past and present will determine the path of how things will develop in the future. The more philosophically interesting aspect of the above quote is this: Words are not accurate, words say too much and too little about a specific thing: words imply more than we intend and words say too little of what we have in mind. For example, “The sky is cloudy,” may give you the image of grey skies. Yet, it is conceivable that the sky is blue despite it being cloudy. When the first passage of the Daodejing says: “The Dao (way) that can be paved is not the eternal constant Dao,” its point is that you can never carve out an accurate path no matter how hard you try to describe it with words. Though we may have a context, the words meant to form a Dao say too much and too little at the same time, and thus cannot accurately describe nor prescribe the right path.

Applying this to Complexity Science may lead to a word of caution about the concept of path dependence. Much of what scientists have described as path dependence is a retroactive reconstruction. It is from a limited narrative of a historical context that we imagine a path by which complex systems develop. This is useful for helping us understand roughly how a complex system has come to be what it presently is. But the danger arises when we try to use it to determine the possible paths the system will traverse in the future. For our ability to construct paths is based on how we construct that narrative, and on our knowledge of a specific context.

One tendency to resolve this issue is to assume that we can fix it by increasing the specific details in the narrative, thus arriving at a more accurate path. However tempting this may be, this solution would compound the very problem stated in the first passage of the Daodejing. To reiterate, words say too much and too little about what we intend. To use more words would be to further obfuscate the matter. It is precisely because of the false belief that with more words, we may acquire a more accurate path (after all, “the Way is constantly nameless”¹²), that the Daodejing demands that we “throw away

Dao. As to a name, if it can be specified as a name, it is not a permanent name. (trans. Hans Georg Moeller, 2007)

“As for the Way, the Way that can be spoken of is not the constant Way; As for names, the name that can be named is not the constant name.” (trans. Robert Henricks, 1989)

¹² *Daodejing*, 32. Translation by Jonathan Sim.

knowledge,”¹³ embrace the simplicity and namelessness of the Dao, and thus arrive at a deeper understanding of it, unobscured by language. This prescription may seem shocking and even counter-productive to the sciences. Nonetheless, the main point emphasised here is that words do not lead us to the eternal and unchanging truth about the matter. One ought not cling to a single narrative of path dependence just because we have a narrative. Multiple narratives exist, and they each have their inaccuracies.

Another problem, especially with historical narratives, is to assume an objective, third-person, god’s-eye view of the situation, when such a narrative is in fact coming from but one of many possible historical narratives about a complex system. According to the Zhuangzi, another Daoist text attributed to the thinker Zhuangzi, it is often the case that we assume that one context only brings to light a specific path, yet what we don’t realise is that we define a path also by means of its negation. I may speak of path A (based on a certain context), yet path A is defined because we are also simultaneously thinking of not-A. The word, “definition,” comes from the Latin, “de” and “finire,” which is to limit or bound completely. A boundary exists to separate one’s property from not-one’s property. Similarly, to define a path is to set boundary conditions on what is and what is not. Yet, within the definition of what is not (e.g. not-A) is a context that encompasses an infinite number of other possible paths. While a specific context may have brought to line just one path, it does not eliminate it does not eliminate other alternative paths. These alternative paths come to light when we change the context, or when we slowly become aware of these other paths co-existing within the same context, but through its negation (not-A).¹⁴

With regards to complexity, on a basic level, we may attempt to adjust our context by incorporating other contexts or narratives from other scientific paradigms or research programmes, so as to expand our awareness of the path dependence of a certain complex system.

On a more profound level, and maybe one where further exploration into this area in science may be worthwhile, if Zhuangzi is indeed right in his thoughts about contexts and paths, how then do we illuminate the other paths encapsulated within the negation (within the not-A that defines A) of the path that is obvious to us (path A)?

2. Patterns of Self-Similarity, Yin-Yang, and the Book of Changes

Another concept in Complexity Science is self-similarity, where complex systems exhibit similar patterns on various levels (micro, meso and macro), like fractal patterns.¹⁵ Patterns are useful for measuring and predicting changes and developments in complex systems. For example, patterns of symmetry breaking are signals for major changes within a system.

¹³ *Daodejing*, 19. Trans. Robert G. Henricks

¹⁴ “This is also that, that is also this. This has its own this/that and that also has its own this/that. So is there really a this/that or isn’t there? When this and that no longer find anything to be their opposites, (or do not see each other as opposites ...), this is called the Pivot of Dao. Once the Pivot finds the centre, so that it can respond infinitely without obstruction, this/self/right is unobstructed and inexhaustible, and that/other/wrong is equally unobstructed and inexhaustible. This is why I said there’s nothing better than using the obvious.” *Zhuangzi*, Chapter 4 in Brook Ziporyn, “How Many are the Ten Thousand Things and I?” in *Hiding the World in the World: Uneven Discourses on the Zhuangzi*, ed. Scott Cook (Albany: State University of New York Press, 2003), p.49

¹⁵ An object is said to be self-similar if it looks "roughly" the same on any scale. Fractals, for example, are a particularly interesting class of self-similar objects (<http://mathworld.wolfram.com/Self-Similarity.html>)

A related idea in Chinese thought is the idea of Yin and Yang.¹⁶ At its most basic, Yin and Yang are just relative labels used to describe opposite, yet complimentary, states of processes. The “Yang” label is applied to processes that are relatively more active; whereas the “Yin” label is applied to processes that are relatively less active or more passive. While conventionally, we speak of Yin and Yang as though they are separate entities, Yin and Yang are actually interconnected and inseparable. In fact, the patterns of self-similarity exist within the system of Yin and Yang. That which is Yang is composed of both Yin and Yang components. The sub-component that is Yang, can be further divided into Yin and Yang once again.

The uniqueness of Yin and Yang is the fact that Yin processes can and will eventually transform into Yang processes while Yang processes can and will transform into Yin processes as well. Underlying this perception of the world is the premise that change is a constant, and in a world where processes are constantly changing from Yin to Yang and vice versa, the harmony (or balance) of Yin and Yang is important. Here harmony does not refer to the Western notion of a state of being, but to the process of perpetuating these cycles of change, allowing Yin to transform into Yang, and vice versa, ad infinitum. A process expanding in its Yang quality cannot (and should not) be balanced with another Yang process, as that would lead to such great imbalance that it would be difficult, if not impossible, to restore it. For example, dealing with an angry man by shouting at him would not resolve the matter, but lead to greater conflict. The interaction of Yang with more Yang results in an excess of Yang, and thus – to use the terminology of complexity – would lead to a pattern of symmetry breaking, resulting in violent changes in the system. Instead, Yang processes are to be countered with Yin processes in order to restore the harmony (and maintain the symmetry between Yin and Yang), e.g. dealing with the angry man calmly would eventually calm him down. Moreover, the entire process of symmetry-breaking within this Yin-Yang framework, may be seen as a component of a far larger Yin-Yang process. Thus, while we may be perceiving symmetry breaking on one scale, on another scale, this break is but a part of the balancing process as Yin and Yang interacts with each other. On this greater scale, symmetry has never been broken.

The use of Yin and Yang is a convenient way, a shorthand if you like, for the early Chinese thinkers to easily make sense of the many factors and processes running their course in a complex system. This approach may be useful to Complexity Science as it is often the case that far too many processes are identified, too many components named to be able to make sense of these myriad factors. Thus, it can be very difficult coming to a decision on how to diagnose or remedy problems that (will) arise in a complex system. It seems that the Chinese perception of the world and its systems as multiple layers of Yin and Yang embedded within each other, is a useful way of approaching complex systems and their emergent phenomena. Ultimately, it is the interaction of the components – i.e. processes – that give rise to emergent phenomenon. By focusing too much on being, on the components that make up the system, it might be easy to miss out on the dynamics of how the emergent phenomenon arises. Instead, by studying complex systems the “Yin Yang” way, that is, by placing focus on the processes of their interaction, and perceiving them in a hierarchical manner, we might be able to better understand the dynamics of the interaction that takes place within a system.

However, the use of Yin and Yang in Chinese thought does not end here. The Yijing (also written as: I-Ching), popularly translated as “The Book of Changes,” goes on to further develop the idea of the interaction between Yin and Yang. The Yijing teaches that change is a constant. The 64 hexagram patterns found in the text “represent all possible forms of change, situations, possibilities, and institutions,” and thus the universe is controlled by “a natural operation of forces which can be

¹⁶ For more information about the concepts of Yin and Yang, we recommend reading: Robin Wang, *Yin Yang: The Way of Heaven and Earth in Chinese Thought and Culture* (New York: Cambridge University Press, 2012).

determined and predicted objectively.”¹⁷ Each pattern of change consists of six lines, each line representing either a Yin or a Yang process. (The top three lines and the bottom three lines are in a sense, representative of the two “personalities” or “characteristics” of that particular moment, interacting with each other) In that sense, each moment of change undergoes six stages, where each stage may be either active or passive. The Great Appendix, added to the end of the *Yijing*, tells us that the sages, having studied the *Yijing*, are prepared well with deep insights on the way things and their situations will unfold over time. Hence these sages have nothing to worry, for they know the precise time to act with the greatest efficacy.¹⁸

It might be interesting to approach the study of Complexity in a way similar to that of the *Yijing*. While there may well be more than 64 patterns of change, it would be worthwhile to investigate if we could abstract a precise number of patterns from the processes of change, as they arise in complex systems. The labels, Yin and Yang, may also serve to help us to better understand and simplify the complex interactions and processes.

If the *Yijing* is right, or at least, if the direction it sets is indeed promising, we might be able to arrive at a set of universal patterns of change that occur across complex systems. This would indeed be most beneficial to understanding the dynamics at work in these systems.

3. Self-Order and Wuwei (無為)

Another concept is emergent self-order, used to describe a peculiar phenomenon where, without a central authority/leader or even despite it, the components or agents in a complex system are able to work in such a way that order emerges from their interactions. Understanding the underlying principles that lead to such emergence is one of the big challenges for complexity science.

The concept of wuwei, often translated as “action by non-action,” does not speak directly about self-order, but it gives us interesting insights on how to manipulate and take advantage of it. To be clear, wuwei does not mean “do nothing.” Rather, it calls upon the actor to take advantage of self-order, or in the case where there is no self-order, to manipulate conditions so as to achieve self-order. In this way, the actor does almost nothing, but is yet capable of achieving everything.

Direct action can often be ineffective, and usually wastes a lot of resources when trying to deal with the matter. To anticipate and stop problems before they arise, or to nib them at their earlier stages, this too is part of wuwei, for it prevents problems from growing so big that they require a lot of effort to resolve them. While the concept is often associated with Daoist philosophy, Confucian philosophy and the Legalist philosophy of Han Feizi also employ the same concept: they call upon the ruler to rule with wuwei.¹⁹

¹⁷ Wing-tsit Chan, *A Source Book in Chinese Philosophy* (Princeton, Princeton University Press, 1963), p.263

¹⁸ For a full description of the efficacy and use of the *Yijing*, please refer to “The Great Appendix” in “The Commentaries” of the *Yijing*.

¹⁹ *Analects* 15.5: “The Master said, ‘If there was a ruler who achieved order without taking any action, it was, perhaps, Shun (legendary sage king). There was nothing for him to do but to hold himself in a respectful posture and to face due south (i.e. to seat on his throne, as the throne faces south).’” (trans. D. C. Lau)

Han Feizi 5: “When an enlightened ruler practices nonaction (*wuwei*) above, the assembled ministers will be anxious and fearful below.” (trans. Joel Sahleen in *Readings in Classical Chinese Philosophy*, ed. Philip J. Ivanhoe & Bryan W. Van Norden (Indianapolis: Hackett Publishing Company, 2001), p.315

For the Confucians, this is achieved through educating society on their social roles and ensuring that they learn and internalise the requirements of those roles. People will then act morally with each other based on reciprocity.²⁰ Failing which, their sense of shame will motivate them to rectify what they have failed to do.²¹ In such a social arrangement, the ruler simply needs to do his role excellently well, and the people will reciprocate and act accordingly. In this way, the ruler does not have to exert too much beyond his own role in order to achieve great things. He has created the conditions that will facilitate the rise of self-order both in peaceful and chaotic times, and thus needs not do anything more other than what is expected of him as a ruler. By dutifully performing his roles, he will set into motion a certain resonance down the hierarchy to perform their roles dutifully as well. Through this, social harmony is achieved by wuwei.

For Han Feizi, the legalist philosopher, the ruler rules by wuwei first by holding on to the beginning or the roots, “so that he may know the source of the ten thousand things, and regulates the guiding thread so that he may understand the starting points of excellence and failure.”²² He does this by establishing a system of policies, with a clear reward and punishment system, and appointing people of merit whom he can trust to carry out their duties (and of course, the system of reward and punishment should motivate them to act automatically). In this way, the ruler is the source of the entire established system, and he does not do anything else, but to allow “names to define themselves and affairs to determine themselves.”²³ Having done so, the ruler does not need to do anything more. He has created the conditions that will facilitate the emergence of self-order during times of peace and chaos.

But the more philosophically interesting aspects of wuwei can be traced back to ideas within the Daoist philosophy. The Daodejing repeatedly prescribes making use of the weak, the hidden, the feminine, so as to overcome the strong, the clear, the masculine.²⁴ When something happens, we often focus our attention to the direct cause of the incident, ignoring (and even forgetting) that other supporting conditions may have contributed to the efficacy of the cause in producing the effect. Without these supporting conditions, the cause is rendered impotent to generate a significant effect (or any for that matter). The Daodejing advises us to turn our attention away from the most obvious to focus on that which is the least obvious. For it is precisely the things that are least obvious to us that gives the most support to small causes, thereby facilitating the rise of bigger problems which by then would be too late for any intervention to be effective. Or if intervention can succeed, it would by then be too costly.

Here, the Daoist strategy of wuwei may be summarised as follows: never approach an emergent problem directly. Always use indirect means, of tweaking the component parts – especially that which appears weak or hidden, as these may be the key supporting conditions for the potency of a cause – so that the emergent problem fades away.

²⁰ Analects 15:24: “Tzu-kung asked, ‘Is there a single word which can be a guide to conduct throughout one’s life?’ The Master said, ‘It is perhaps the word “*shu* (恕 reciprocity)”. Do not impose on others what you yourself do not desire.’ (trans. D. C. Lau)

²¹ *Analects* 2.3: The Master said, ‘Guide them by edicts, keep them in line with punishments, and the common people will stay out of trouble but will have no sense of shame. Guide them by virtue, keep them in line with the rites, and they will, besides having a sense of shame, reform themselves.’ (trans. D. C. Lau)

²² *Readings in Classical Chinese Philosophy*, ed. Philip J. Ivanhoe & Bryan W. Van Norden (Indianapolis: Hackett Publishing Company, 2001), p.314 (*Han Feizi* 5)

²³ *Ibid.*

²⁴ See *Daodejing*, 28, 36,40, 43, 55, 61, and 78.

4. Network Nodes and Links, and the Confucian Conception of Relations and Roles

One path to understanding complex systems is to study its networks of nodes and links. We may compare that way of looking at complex systems with Confucian philosophy that attaches high values to relations. By virtue of one's position in life, a person possesses many different roles:²⁵ he is a son of his father, a husband to his wife, a father to his children, an employee to his boss, a superior to his subordinates, etc. Each role contains certain normative expectations, coupled with ritually appropriate ways of conducting one's self towards the other (ritual in the Confucian sense is more akin to social etiquette and even best practices of a community).²⁶ The whole system of relations is premised on reciprocity. Superficially, a person may reciprocate simply because it is customary (and thus rude not to), but the ideal situation (which ritual is meant to inculcate in the formative process) is that the roles and expectations are fulfilled, and relational actions reciprocated out of benevolence. The more excellent a person is in his roles, the more people are moved by their good hearts, (or by a sense of shame), to act accordingly.²⁷ As mentioned in the previous section, the ruler is able to govern with wuwei (in the Confucian sense), by living up to his roles and duties. A few exemplary persons capable of living out their roles and expectations have the power to resonate their virtue and thus galvanise the people toward social order.

Regardless of whether one agrees with this view of establishing social harmony, there is a conceptualisation here of networks, and the ability of certain virtuous nodes to influence other nodes in the network by their excellent performance of duties. This implicit understanding of networks in the Confucian worldview may give us a glimpse of new ways of studying networks within a complex system, beyond the abstract simplification of individuals in a network as mere nodes (vertices) and links (edges).

Rather than to treat a node purely as an abstract node, perhaps it may be beneficial to add a layer of nodal roles and nodal relations (hierarchical, even), including the performance level of a node in a particular relation, to enrich our understanding of the types and quality of relations in a complex system. This may allow us to better understand the way certain information is transmitted between nodes – not just the direction of transmission, but perhaps why unidirectional or bidirectional transmission is even possible between nodes, or why certain nodes are more effective in transmitting information.

²⁵ Typically in Confucian philosophy, there are five basic types of relationships: (1) ruler and subject, or superior and inferior; (2) parent and child; (3) elder sibling and younger sibling; (4) husband and wife; (5) friend and friend. It is important to note that the duties and expectations of roles are bi-directional, that is, each has a part to play towards the other, and premised on the principle of reciprocity.

²⁶ *Analects* 12:11: "Duke Ching of Ch'i asked Confucius about government. Confucius answered, 'Let the ruler be a ruler, the subject a subject, the father a father, the son a son.' The Duke said, 'Splendid! Truly, if the ruler be not a ruler, the subject not a subject, the father not a father, the son not a son, then even if there be grain, would I get to eat it?'"

²⁷ *Analects* 2:3: The Master said, 'Guide them by edicts, keep them in line with punishments, and the common people will stay out of trouble but will have no sense of shame. Guide them by virtue, keep them in line with the rites, and they will, besides having a sense of shame, reform themselves.' (trans. D. C. Lau)

5. The Chinese Concept of Resonance: Ganying, Neither Causation nor Statistical Correlation

Throughout the classical period, the early Chinese thinkers developed ideas of resonance known as *ganying* (感應, literally “stimulus” and “response”), analogous to the vibratory sympathetic resonance one can observe when a vibrating pitchfork, placed near the string of a musical instrument to vibrate, will result in the string vibrating. It was only later that the concept of *ganying* developed into a sophisticated concept, where “the human world and the humans therein are a miniature of the macrocosmic heaven. An event in the microcosmic world would cause a corresponding effect in heaven and vice versa.”²⁸

Here, the Chinese thinkers did not think of causation in the scientific sense of causation. Neither did they think of it as a kind of statistical correlation. *Ganying* was a concept that referred to something in between scientific causation and statistical correlation.

Though the idea originated from vibratory sympathetic resonance, early thinkers applied this mode of thinking to ritual actions. An example to illustrate the *ganying* can be found in a large dance performance. Every dancer in the performance has their own roles and specific set of actions to carry out. Unlike an orchestra where there is a conductor, there is no central leader or conductor in a dance. By performing the dance well, dancers are able to take cues from each other and respond accordingly to each other’s cues, synchronising and even adjusting their actions in relation to one another. They know when to start and when to stop; when to turn, and when to move in a certain manner. Each dancer influences the actions of every other dancer. Yet, we cannot say that each dancer causes the other dances to act. There is a correlation in the actions of the dancers, but of course, it is not a statistical correlation. The dancers resonate their respective actions and responses amongst themselves.

It is from this idea that the early Chinese thinkers extended the concept of resonance to link the actions of humans with the actions of Heaven and Earth. It is as if the myriad things of Heaven, Humanity, and Earth are locked in a dance with each other. Interacting and engaging with one another based on certain cues. As Heaven changes the season, Earth responds by changing the colours of the leaves, and humans respond to the change by changing their activity. Affairs are harmonious and prosperous when the actions are executed in a timely way, thus everything runs like clockwork, and in ways that we expect them to.

The early medieval Chinese thinker, Dong Zhongshu, has this to say about resonance:

“If now water be poured on level ground, it will avoid the dry area and run to the wet area, whereas if two identical pieces of firewood are exposed to fire, the fire will avoid the wet piece and go to the dry one. All things avoid what is different from them and follow what is similar to them. ... There is nothing supernatural in this. It is their natural course that they do so. ... When the sky is dark and it is about to rain, a person’s sickness affects him first, because the force of yin rises in response. When the sky is dark and it is about to rain, people want to sleep, because the material force of yin is at work. People who are sad want to lie down, because the yin of sadness and lying down seek each other. And people who are happy do not want to lie down because the yang of happiness and staying up require each other. Because of the night, the water level rises in some degree. Because of the east wind, the wine becomes further fermented. When the night comes, the sick person’s sickness becomes worse. When the day is about to dawn, cocks all crow and press on each other, their

²⁸ Yuet-Kueng Lo, “Destiny and Retribution in Early Medieval China,” in *Philosophy and Religion in Early Medieval China*, eds. Alan K. L. Chan & Yuet-Keung Lo, (Albany: State University of New York Press, 2010), p.342.

force becoming more and more refined. Therefore the yang reinforces the yang and the yin reinforces the yin, for the forces of yin and yang can naturally augment or diminish things because of their similarity in kind. Heaven possesses yin and yang and man also possesses yin and yang. When the universe's material force of yin arises, man's material force of yin arises in response. Conversely, when man's material force of yin arises, that of the universe should also arise in response. The principle is the same. He who understands this, when he wishes to bring forth rain, will activate the yin in man in order to arouse the yin of the universe. When he wishes to stop rain, he will activate the yang in man in order to arouse the yang of the universe. Therefore the bringing forth of rain is nothing supernatural. People suspect that it is supernatural because its principle is subtle and wonderful. It is not only the material forces of yin and yang that can advance or withdraw according to their kind. Even the way misfortunes, calamities, and blessings are produced follows the same principle. In all cases one starts something himself and other things become active in response according to their kind. ... In reality things are caused, but the cause is invisible."²⁹

It was only in the late classical period to early medieval period that Chinese thinkers began classifying all the objects of Heaven and Earth into categories, known as the Five Phases (五行 *wuxing*), similar to the Greek four elements, but referring to processes rather than things.³⁰ Not only is there a resonant relationship between the microcosm of humans and the macrocosm of Heaven and Earth, but that things within a particular phase (or category) could also resonate with each other, thus activating certain sets of behaviours. For example, a particular colour, tone, or flavour, could resonate with a particular organ or emotion within a person (thus affecting one's decisions and actions), or even to the extent of resonating with certain aspects of the earth or celestial realm (or vice versa).

While we now have a better understanding of the causal mechanisms underlying many of the phenomena described above, it is easy to miss the point if we focus solely on the unscientific qualities of the claims. The point, rather, is that the concept of *ganying* (resonance) can be very useful for exploring the concept of emergent phenomena in complex systems, where evidence of direct causation or statistical correlation are absent. This idea (or something similar) may be very useful because it adds a link to the various levels (or scales) of the way we model phenomena in a system. Each model of a phenomenon is confined within a particular scale. But ideas like *ganying* provide a means for both a vertical and horizontal dimension of interaction. This concept might be worth exploring and further refining in Complexity Science as it provides a new layer of dynamics that links various scales of phenomena. It might also provide a way to look at different time scales along which interactions within complex systems occur.

Final considerations

We have explored five ideas in classical Chinese thought, three of which share some similarity or relation with thoughts and concepts that have been developed in complexity science, while the last two explore ideas that might be worth introducing to the study of complexity. The list above is not at all exhaustive, but we hope that this discussion provides a level of credibility of the potential for Complexity Science to be enriched by the thoughts of early thinkers, such as those of the classical Chinese Philosophers as we have discussed in this paper.

²⁹ "Tung Chung-shu" in *A Source Book in Chinese Philosophy*, trans. Wing-tsit Chan (Princeton, Princeton University Press, 1963), pp. 282-284

³⁰ *Wuxing* literally translates to, "five actions or operations." The five phases are: Metal, Wood, Water, Fire and Earth.

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