

Note

Cybercrime as Complex Systems

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Introduction

Cybercrime is one of the most important current issues in public safety and security. For both practical and academical purposes, the nature of cybercrime must be clarified. Criminology has been focusing on this category of crime for about two decades and showed the eternity and universality of traditional criminological theories could be applicable to cybercriminals.

However, Lusthaus 2018 showed that business people in the “Industry of Anonymity,” the flourishing world of crackers in the dark side of cyberspace, seemed to be brought up through different path-ways from traditional street gangs. Most of them were educated in high-leveled academic institutes and seemed to have nothing to do with troubles in their families or neighbors.

In addition, previous researches rarely focused on the most prominent feature of cybercrime and cyberspace: rapidly changing. Cyberspace, the environment of cybercrime, is rapidly changing, and so are the tricks of cybercrime. These phenomena occur not by accident, but by the intentions of “platformers,” creators of cyberspace, or cybercriminals. In the most traditional criminological theories, living environments of offenders are given as unchangeable conditions for them.

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I used to be the Director of Cybercrime in the National Police Agency of Japan, and tackled continually emerging new types of cybercrime. The essential task of law enforcement has been to recognize the changes of cybercrimes and to flexibly adopt new strategies. The types of cybercrimes or their changing patterns seem to continue only for a short period of time, and suddenly change dramatically. In addition, the *modus operandi* of cybercrimes are somewhat different among countries or the regions. We have to learn not only eternal and universal truths of cybercrime, but also its mechanisms of change and differences.

This study is not an empirical research, but a proposal of a theoretical framework for understanding cybercrime through deductive argument based on both commonly shared perception of cyberspace and cybercrime and the ideas of 'complex system' which may be unfamiliar to the most readers of this paper.

This paper first focuses on rapidly changing as the feature of cyberspace and cybercrime, and creativity as its cause. Second, we will discuss why and how creativity is possible. Creativity is construction of unique and favorable new structures in human mind, which is different from and better than existing creatures. This means that creativity requires 'individuality', difference with others, and 'value', eager to the better world. Third, to understand the ideas of individuality and value, I will introduce the concept of 'self-organization', with which an entity can construct and maintain its unique structure. Self-organization is the core idea of the theory of 'complex system' and, from my perspective, is the missing link between universality and individuality in science. Finally, I recommend to introduce the theory of 'complex system', a new scientific methodology, into criminology in order to understand rapidly changing cyberspace and cybercrime.

1. Feature of Cyberspace and Cybercrime

A prominent feature of cyberspace and cybercrime is rapidly changing. It's said that cyberspace passes in the "Dog Year," because lifespan of a dog is said to be one-seventh of that of humans. In fact, new technologies emerge year by year, or day by day. Similarly, new methods of cybercrime appear continually. We often see zero-day attacks, which are conducted before the patch of vulnerabilities of a new system is released.

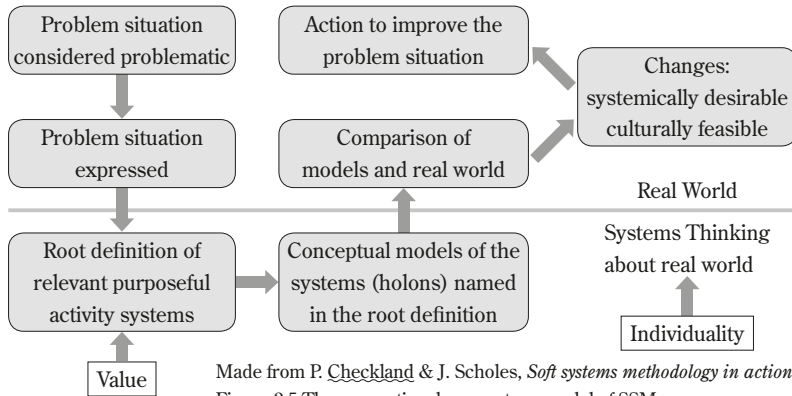
Chart 1. History of cyberspace and cybercrime

History of Cyberspace	History of Cybercrime
1969: ARPANET	1971: Creeper
1984: DNS	1986: Brain
1986: NSFNET	1987: Vienna virus
1991: WWW	1988: Morris Worm
1995: Amazon	1999: Melissa
1996: Webex	2000: ILOVEYOU
1998: Google	2002: Code Red
2004: Facebook	2003: SQL Slammer
2006: Twitter	2009: Gumbler
2010: iPhone	2010: Stuxnet
2011: Zoom	2016: Mirai
2019: Covit 19	2017: WannaCry
	2020: Emotet

But why does these rapid changes occur in cyberspace and cybercrime? Does it happen by accident? Does the DNA of cybercriminals mutate constantly? No, the rapidly changing cyberspace is intentionally made by platformers, system designers, programmers, code-writers and other actors of cyberspace with their creativity.

Figure 1 shows the typical pattern with which programmers make a new computer system.

Figure 1. Creation of a New System



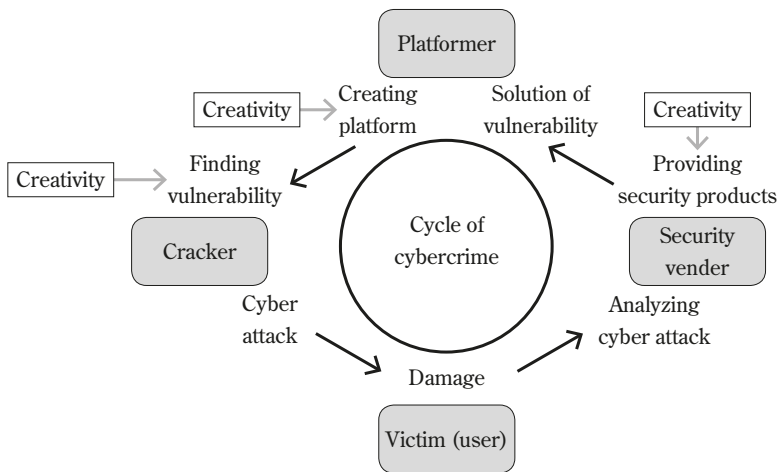
Made from P. Checkland & J. Scholes, *Soft systems methodology in action*, Figure 2.5 The conventional seven-stage model of SSM
Squares are added by Shikata

Figure 1 originally made by P. Checkland, one of the most famous systems scientists, shows a typical pattern of how a system engineer integrates ideas and construct a new system. Engineers create their own imaginary systems in mind through mapping the existing system in the real world, but it is not the true copy of the real system. It is their own construction in mind. This means that engineers have their own identities independent from the real world.

In addition, an engineer evaluates this imaginary system and find a 'problem' in it from the view point of some value. Furthermore, an engineer envisages 'purposeful' system different from the real system from the view point of the value. 'Problem' or 'purposeful' are words expressing evaluation from the viewpoint of some value. This means that an engineer has some value in mind. Value is human-made concept because natural things themselves have no sense of good or bad. As far as people seek better world, new systems will be continually created one after another. Information technology market requires this movement strongly.

Then, why does cybercrime rapidly change as cyberspace? Dupont 2020 found interactions among industrial community, criminal community and security community, based on the ecological theory of criminology. Inspired by Dupont, Shikata 2021 depicted 'cycle of cybercrime' (see Figure 2). Platformers are making new platforms one after another required by the market. New platforms almost always entail with some vulnerabilities. Cybercriminals promptly find these vulnerabilities and create new methods to deceive systems or people before security vendors find it and provide security products.

Figure 2. Cycle of Cybercrime



2. Cause of Creativity

It can be said that modern science has long been disinterested in creativity or innovation, other than J.A. Schumpeter and several theorists. The mechanism of creativity still seems unclear so far.

Before further discussion, I would like to confirm what creativity means. A typical definition of 'creativity' is "the ability to make or otherwise bring into existence something new."¹⁾ This means that creativity requires the ability to make a new thing different from other existing things. In addition, 'ability' means "the physical or mental power or skill needed to do something."²⁾ As far as human-beings' ability is concerned, it should entail with will, intention, desire or eager, not by chance. As we seen in engineers before, creativity requires creator's independent identity and value independent from the real world.

Thus, we encounter the long unsolved question in criminology: free will versus decision by the laws of nature. If the laws of nature decide everything as modern scientists have long believed, identity and value independent from the laws of nature are impossible, and creativity must be decided by the eternal and universal rules, that is far different from our common understanding of creativity. Brain, where human mind exists, is a natural thing designed by the human DNA which seems to be decided by the laws of nature, therefore, human mind logically seems also to be decided by the laws of nature. On the other hand, free will or creativity undecided by the laws of nature seem to really exist with our 'natural' sense. To believe that free will or creativity really exists, we have to find the mechanism in which independent identity and value are constructed in mind at least partly free from the laws of nature, although mind is physically located in brain.

3. Self-organization as the missing link between universality and individuality

The core idea of this paper is that the concept of self-organization is the

1) www.britannica.com/topic/creativity

2) <https://dictionary.cambridge.org/dictionary/english>

missing link between universality and individuality, between the laws of nature and free will, and is necessary to understand rapidly changing cyberspace and cybercrime made by creativity of cyber actors.

Self-organization is a function or mechanism with which a complex system organizes elements, maintains and duplicates itself. Complex system means a setting of elements formed by the interactions or relationships among these elements, or between the elements and the whole system. It may be a solid structure, or may be only tentative interactions or relationships.

A typical example of self-organizing system is the cell of living organs. A cell ingests, organizes and excretes molecules (such as amino acids and H₂O) as its elements in order to maintain and duplicate itself along with the genetic information in DNA. An ecosystem in nature is also a self-organizing system, because it recovers by itself, even if it encounters a large natural disaster, such as an earthquake or typhoon, unless the damage exceeds a certain threshold. An organization of people is another example of self-organizing system. An organization such as a corporation will continue to survive even if the managers, employees or properties change. A group of people such as members of an academic school or a national in a country can be seen as a self-organizing system formed by the shared culture as a loose code.

When an existence becomes a self-organizing system, its nature changes dramatically. The self-organizing system comes to have some control on itself and have an essential individuality. The different shapes of the stones on the riverbank are only accidental, however, the differences in individual personalities, corporate forms and organizational cultures, or nations' culture are maintained and developed by these own systems, not just a result of chance.

A self-organizing system gradually changes itself in response to the changes of environments in the past, or with desire to develop itself. In addi-

tion, because it irreversibly accumulates those changes in the past, each system evolves through the different path-way. Thus, the evolution of self-organization is said to have 'path dependency'. A typical path dependency of self-organizing systems is shown in the tree diagram of species as a result of the evolution of biological species. Path dependency is a source of individuality of a self-organizing system.

The concept of self-organization is not my unique idea. It can be found in almost all fields of science, including physics, chemistry, biology, physiology, sociology and other science, but rarely in criminology. A famous physicist I. Prigogine discovered the firstly found self-organizing system called 'dissipative structure,' a whirlpool appearing in some energy flow. The vortex of tornadoes and typhoons is also a self-organizing system that occurs according to some continuous energy flow. Due to the diverse energy flows and the reacting substances, it creates diversity in the structure of the substance. Since then, there have been many studies in the fields of physics and chemistry based on the theory of complex system involving the concept of self-organization.

A biologist, L.von Bertalanffy proposed 'General System Theory' depicting living creatures as self-organizing systems interacting with environment. Bertalanffy advocated understanding living things as systems in 'fluid equilibrium', which constantly exchanged substances and energy with the environment to maintain themselves. That is, the living thing is a dynamic self-organizing system that is open to the environmental systems. The mechanism of immune system, hormonal balance and photosynthesis are examples of fluid equilibrium in a self-organizing open system.

DNA is the key to the self-organizing nature of living organisms. With the advent of DNA, life bodies gain the function of self-repair and self-replication. That is, even if an environmental change occurs, the living body maintains self-organization by repairing its damaged self or adapting to the environ-

mental change through mutation, unless the environmental change destroys the self-organization of the living body. In addition to passive adaption to the environment, living things actively approach to the environment and maintain self-organization through relocation, housing, manufacture of tools or other positive actions. Furthermore, through the reproduction of survivors, the species is preserved even if individual living bodies die. The diversity caused by mutations is maintained as long as self-organization of living body functions. The function of mutation and natural selection causes living things to irreversibly strengthen their ability of self-organization, making species more viable. This is the path-dependent irreversible evolution of species. DNA gives living things partial independence and individuality from the laws of nature controlling the material world.

Maturana and Varela, who have studied neurophysiology of birds, found that recognition of the external world in the animals' brain is not a snapshot of the scene as it is, but a mapping constructed by the neural system in the brain, a topological relationship formed by a network of interacting neurons. Subsequent developments in psychology have revealed that human recognition is made by a cognitive framework called 'schema' or 'mental model'. Thelen & Smith 1994 states cognitive "development is the outcome of the self-organizing process of continually active living systems." In addition, human recognition is accompanied by an evaluation entailed with emotion or value. According to the growth theory of psychology, children make their emotion developed into social values in the growth process, which they use as a scale of evaluation.

Under the development of the theory of complex system described above, I proposed a model to define a person's identity as a self-organizing system combining the recognition framework and the value system, which is constructed by the neural network in brain (Shikata 2007). If this model is true, human being obtain identity as a self-organizing system constructed in the

world of thoughts, based on but partly independent from the living organ of the body which obeys the laws of nature. This relationship between identity and brain seems similar to the one between software and hardware of computer. While the function of a software is influenced by the performance of hardware because software is running on the hardware, performance of computers differs with the same hardware but different software. In the same way, human identity works partly independent from and partly dependent on the living organ of brain which works under the laws of nature. Because the will is led by a person's identity, it is decided partly independent from and partly dependent on the laws of nature. This is the cause of free will, which is also partly influenced by environments under the laws of nature. And this is the reason why human identity or personality has both individuality and universality. The independence from the laws of nature can afford identity to be different from 'the standard' decided by the laws of nature, and the self-organizing feature of identity maintain itself different from others.

Identity is also developed through communication with others. Comparing it to the computer analogy above, it is equivalent to that a programmer copies a part of an existing software and pasts it into the new one. The development of identity is usually greatly influenced by the family, since human self-reproduction as an organism is made with a spouse of a different sex and forming a family, and children grow there. Therefore, the identities of people develop through a similar way as long as the family system is usually common among the people in the same culture, while such identities are different under the influence of family diversity. Similarly, identities of people are influenced by neighborhood, peer groups, corporations or nation state. This means that people partly share the common recognition framework and value system, while each people have their own unique recognition and value. This is the source of individuality and creativity in thoughts.

Distinguish nature of the human mind as a self-organizing system is that it includes values with which it tries to evolve itself. Such a system with its own values can be called as a self-growing system. In addition, most individuals and organizations form their own values and set their own purposes. Value system is also a self-organizing system constructed in mind. A complex system that grows one's values in identity can be called a "self-identifying system" (Shikata 2007). These systems still have a common nature, since they are often affected by introducing or imitating parts of other people's identities, however, they nurture their individuality and control themselves with their own unique values, independent from the universal laws of nature. Individuality of human mind is accelerated by individual values.

Furthermore, human beings can envision new systems in mind based on their own recognition and values. This is the creativity of self-growing system. I proposed another model in which creativity is composed of and processed by three intellectual abilities (Shikata 2007); Firstly, the ability to recognize the current situation of the real world, secondly the ability to set values for which the society shall be improved, and thirdly, the ability to envision a new system that is better than the current situation in light of those values. These three abilities can be seen in Figure 1 described above which shows the programmers' process to create a new system. With their creativity, human beings come to change some of the rules of personal and social development, and to control it with their own hands. While the laws of nature still control people and the society to a considerable extent, human and social changes are not led by the fixed rule inherent in the system or by a stable external environment, but by the values or goals which they set by themselves. For example, creativity of platformers who introduce brand-new systems into the cyberspace one after another seems quite free in thoughts, not limited to universal laws outside the system, such as the laws of nature or historical laws.

As a conclusion, the concept of self-organization is the missing link between universality and individuality, explaining why and how human mind running in the natural organ of brain has free will but also is influenced by the laws of nature. Creativity, the cause of rapidly changing cyberspace and cybercrime, can be understood as a work of human beings who are self-growing system with their values.

4. Implications to the Research of Cyberspace and Cybercrime

This section describes the significance of the concept of self-organization and the theory of complex system on the philosophy of science. The question is how to recognize individuality and creativity in human mind and human society.

Modern science is an academic methodology which is designed to understand the eternal and universal laws of nature, adopting the statistical verification which statistically questions the truth of hypotheses (theories) based on numerical data obtained through experiments and observations. Descartes proposed the basic idea of modern science, in order to free science from the collective fallacy including theology. It is true that modern science has discovered so many laws of nature and will continue to do so.

However, criticizing the methodology of modern science, various theories and complex system theory emerged focusing on two theoretical ideas. Firstly, new theories accuse the modern science of its reductionism, with which modern scientists analyze things divided into the smaller elements or parts. Sociology, for example, criticizes existing schools' focusing on individuals, targets the overall picture of society. Many of today's complex system theories seems to focus primarily on criticism of the reductionism of modern science. In responding to the first criticism, modern science urges that the relationship between the whole and elements can be modeled in simultaneous equations which can be verified by statistical verification. This means

that reductionism is not a critical nature of the modern science.

The second criticism is for the verificationism of the modern science, mainly led by statistical validation. Verificationism is accused in several viewpoints. First of all, the meaning, which is topologically decided among the elements or with the relationship between the whole and elements, cannot be understood by statistical analysis, in which ample meanings are chipped off when the statistical data are extracted from the real world. Secondly, statistical data cannot be always observed in the real human society, especially data relating crimes.

The third criticism is more essential to reveal a structural shortcoming of verificationism, arguing that while verificationism is an excellent methodology for science as long as the events are controlled by eternal and universal laws of nature, since statistical verification assumes that the nature of the population to be observed is constant in time and space. However, it is not an appropriate tool to understand individuality and change that is not controlled by eternal and universal laws.

The self-organizing system, as mentioned above, is partly independent and partly controlled by the laws of nature. This means that statistical verification is applicable to the constant aspects of the nature of the system, but not to individual or changing aspects. As discussed above, a self-organizing system irregularly evolves by itself independent from the laws of nature, meaning that the population to be observed is not constant in the world of complex system. Through the observation on the mechanism of the self-organizing system and on the movement of the self-evolving, researchers can predict only for a limited term and space while the 'fluid equilibrium' of the self-organizing system remains until the advent of relocation to the next 'fluid equilibrium', including the creation of brand-new platform in cyberspace. These observations can be successful through direct observation of the target by the researchers or direct interview with actors as Lusthaus did in the

“Industry of Anonymity”, which are called qualitative method of research.

Cyberspace and cybercrime are filled with creativity, and continue to evolve themselves and change irregularly. As I said at the beginning of this paper, practical work of encountering cybercrime focuses on the rapidly changing tricks of the crime, but not on its eternal and universal feature. The most important thing to detect and prevent cybercrime is to grasp the rapidly changing features of cybercrime as fast as possible, that is to find symptoms or attempts of cybercriminals before their truly criminal acts, to observe newly-spammed malware, or to discover the infrastructures for cybercrime such as darkweb, botnets or dark crypto-currency. In order to achieve this, there should be some surveillant system and information gathering system on cybercrime with the cooperation among law enforcement, security industry and Internet users. Current countermeasures against cybercrime in many developed countries seem to be along with the tactics stated here.

Conclusion

A prominent feature of cyberspace and cybercrime is rapidly changing, due to the creativity of platformers, crackers and security vendors. The origins of the creativity are individuality and value in the human mind as a self-organizing system.

Self-organization is a function or a mechanism with which a complex system organizes elements, and maintains and duplicates itself. Complex system means a setting of elements formed by the interaction or relationship among these elements or between the elements and the whole system.

When an existence becomes a self-organizing system, its nature changes dramatically. A self-organizing system comes to have some control on itself and an essential individuality, while it is partly influenced by the laws of nature, because each element of the system is a natural thing. A self-organizing

system has both universality and individuality. Researchers need both quantitative and qualitative researches in order to understand self-organizing systems, such as cyberspace and cybercrime.

The identity of a person can be seen as a self-organizing system combining the recognition framework and the value system, constructed by the neural network in brain. Creativity makes a new system through the three steps process; firstly, recognizing the current situation of the real world; secondly setting values for which the society shall be improved; and thirdly, envisioning a new system that is better than the current situation in light of those values. This process is led by the recognition and value in mind.

Statistical verification in modern science is applicable to the constant aspects of the nature of the system, but not to the individual or changing aspects. Through the observation on the mechanism of the self-organizing system and on the movement of the self-evolving, researchers can predict only for a limited term and space while the 'fluid equilibrium' of the self-organizing system remains until the advent of relocation to the next 'fluid equilibrium'. These observations can be successful through direct observation of the target by the researchers or direct interview with actors, which are called as qualitative method of research.

Cyberspace and cybercrime are filled with creativity, and continue to evolve themselves and change irregularly. The most important thing to detect and prevent cybercrime is to grasp the rapidly changing cybercrimes as fast as possible, that is to find symptoms or attempts of cybercriminals before their truly criminal acts, to observe newly-released malware, or to discover the infrastructures for cybercrime such as darkweb, botnets or dark crypto-currency. In order to achieve this, it is necessary to have some sort of surveillant system and information gathering system on cybercrime in cooperation with law enforcement, security industry and Internet users.

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