TraFST
解説/Review
特集：**Society5.0**，超スマート社会に向けた新しい価値を創造する

Behavioral Economics of Addiction in the Age of a Super Smart Society: Society 5.0

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Abstract– In behavioral economics, violation of rationality in human judgment and decision making has been investigated. In neoclassical economics, on the contrary, almost all human behavior (including addiction) has been assumed to be rational. Recent developments in Neuroeconomics have revealed neural foundations for human judgment and decision making. Cyber technologies offer new risks for new types of addiction (e.g., internet addiction, online video game addiction, and smartphone addiction); while these technologies can potentially offer new intervention methods for the treatment of addiction. In this review, current findings in the studies of addiction in the age of "*super smart society*" (i.e., societies highly digitized and connected via SNSs) are introduced and future directions are discussed.

Keywords– Neuroeconomics, Behavioral economics, Addiction, Smart society

1. Introduction

According to the Japanese governmental official website (`https://www.gov-online.go.jp/cam/s5/eng/index.html`), "*Society 5.0 represents the 5th form of society in our human history, chronologically following hunting, farming, industry, and information. The Fourth Industrial Revolution is creating new values and services one after another, bringing a richer life to all.*" The key technologies of the super smart societies include telemedicine, AI nursing, drone deliveries, and so on. The Transdisciplinary Federation of Science and Technology ("横幹連合" Oukan Rengo, in Japanese) has a number of opportunities to contribute to this innovative changes in our societies by collaborating with diverse academic societies including the Association for Behavioral Economics and Finance in Japan.

In this review article, potential risks and opportunities emerging from new technologies in the super smart societies which are related to addiction are introduced and analyzed by means of quantitative models developed in behavioral economics. Future directions in academic research and social applications of the behavioral economics of addiction with new cyber-technologies are discussed. There are several reasons for our focus on addiction. First, as cybertechnologies penetrate into our daily life, new types of addiction, e.g., "*Facebook addiction*" and "*Smartphone addiction*" have begun to draw much attention [Pontes *et al.*, 2018]. Second, owing to developments in new technologies, novel methods to assess and intervene in individual health problems (including addictive behaviors) have been introduced [Ferreri *et al.*, 2018)] Third, addiction has been extensively investigated in the discipline of behavioral and neural economics [Takahashi, 2009], since addiction is, seemingly, one of the most irrational behavior. It is to be noted that the Association for Behavioral Economics and Finance has been tackling the problems of addiction via the economic theory of addiction and self-control problems.

2. Empirical findings in addiction in the Smart Society

Problematic Internet use and Internet addiction, the excessive use of information and communication technologies have been recognized as problematic behaviors for nearly two decades [Young, 1998]. The concept of Internet addiction was originally proposed by Ivan Goldberg in 1995 on a chat forum for psychiatrists. Recently, it has been proposed that excessive use of video games and Facebook are markers of cyber addiction [Suissa, 2015]. The author proposed a psychosocial approach to Internet addiction such as

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Facebook addiction, since Individualism and the emptiness of social ties may be potential risk factors for Facebook addiction. Facebook addiction Disorder can be defined [Nadkarni & Hofmann, 2012] as follows: "*When people are afraid to disconnect from Facebook because they think they are going to miss something important.*"

In terms of neurobiological foundations for Facebook addiction, Montag *et al.* [Montag *et al.*, 2017] utilized functional Magnetic Resonance Imaging to examine neural correlates of Facebook addiction. They observed that the nucleus accumbens, a brain region, has an important role in Facebook addiction. Regarding molecular mechanisms of Internet addiction, a neurotransmitter Dopamine [Han *et al.*, 2007] and a neuropeptide Oxytocin [Insel, 2010] may have important mediating roles. Recently, Kuss *et al.* [Kuss *et al.*, 2018] reviewed studies of neurobiological correlates in Internet Gaming Disorder. They concluded that "*(Internet) gaming addicts have poorer response-inhibition and emotion regulation, impaired prefrontal cortex (PFC) functioning and cognitive control, poorer working memory and decision-making capabilities, decreased visual and auditory functioning, and a deficiency in their neuronal reward system, similar to those found in individuals with substance-related addictions.*" Therefore, it is recommended that Internet addiction is studied in a manner which is common to other more conventional addictions such as alcoholism [Nicols & Martin, 1993] and habitual smoking [Ohmura, Takahashi, Kitamura, 2005]. Notably, time-discount rate, an economic parameter indicating impulsivity, has been shown to mediate the relationship between posterior insular cortex volume and social media addiction symptoms [Turel *et al.*, 2018]. This finding suggests that economic approaches may be beneficial for a better understanding of social media addiction.

3. Treatment of addiction in a Super Smart Society

New cybertechnologies can profoundly change the manner we understand and treat health problems and addictive disorders. Importantly, novel means of collecting live individual data, computerized questionnaires, and the use of passive (i.e., not actively intervened or controlled, just observatory) data, in the Big Data age. Furthermore, applications of artificial intelligence, e.g., machine learning may improve the diagnosis and classification of individual patients based on data patterns which have not consciously been considered by clinicians in the past. Additionally, remote and automated medical interventions (web/smartphone-based applications) with the help of virtual reality and neurofeedback are or at least will be, available in a future Super Smart Society. We now introduce several future concepts of technological innovations potentially useful for assessing and intervening in addictive behaviors, following Ferreri and colleagues' recent reviewing article [Ferreri *et al.*, 2018].

3.1 e-health

The combined use of electronic communications information technology in the health sector has been defined as "e-health". The representative examples are "telehealth" (health mediated by telecommunications tools such as mobile phones) and robotics (a set of techniques using automatic machines and medical robots).

3.2 Clinical Decision Support System

Computer-based tools supporting the decision-making process, to facilitate organizational processes and provide clinicians with information about patients' clinical status may be effective. The US Food and Drug Administration (FDA) recently authorized a smartphone-based e-health program.

3.3 Machine Learning

This is the subdiscipline of artificial intelligence that gives computers the abilities to learn without explicit pre-program. Machine learning may help accurate classification and diagnosis of patients' patterns.

3.4 Computerized adaptive testing (CAT)

This system automatically adapt questionnaire items to the answers provided by the patient to previous items, using a big data. In psychiatry, "embodied conversational agents" have been developed.

3.5 Ecologically momentum assessment

The use of smartphone apps allows patients to maintain an accurate diary of their clinical status. Alcohol use and PTSD (post-traumatic stress disorder) have been treated with this methodology.

3.6 Digital phenotyping

This technique can capture specific characteristics of psychiatric disorders by computerized measurement tools. Also, the characteristics can be objectified and quantified by computer tools, constituting an "e-semiotics".

3.7 Biofeedback or neurofeedback

Painless, non-invasive methods including the capture biometric data (EEG, ECG, SCR, body temperature etc.) and feeding them back to patients themselves in a real time manner so that they learn how to promote or inhibit brain activities have been developed. This computerized methods may enhance patients' self-control.

Overall, active and real time data obtained in a continuous manner (via smartphone, biosensors or connected objects, i.e., IoT) in a Super Smart Society may help assessment of addictive behaviors and other problematic behaviors. However, important ethical issues (e.g., individuals' privacy and data piracy) should be resolved before wide acceptance of these innovations in the future societies.

4. Behavioral economic approaches to addiction in a Super Smart Society

Addiction has also been studied in economics. For instance, Gary Becker, a Nobel prize-winning economist, proposed a theory of rational addiction [Becker, 1988]. In the (neoclassical) economic theory of addiction, Becker and Murphy modeled addictions as the implementation of a forward-looking consumption plan made under rational considerations of tradeoff between immediate pleasure due to drug intake and delayed health problems due to the past drug consumptions, where the individual is entirely committed toward maximizing utility with exponential time discounting (devaluation of future rewards as delay until its receipt increases). In exponential discounting, even drug intake might be rational, since the preference for drug use over future health does not change over time.

However, later studies in behavioral economics have revealed that human behavior in time discounting is not exponential [Thaler, 1981]. In actual human behavior, time discounting is "hyperbolic", in other words, people's time preference reverses over time (referred to as "dynamic inconsistency"). Therefore, in neuroeconomic studies of addictions, neurobiological correlates of time discounting have extensively been investigated.

In people with Internet Gaming Disorder (defined as the persistent use of online games in spite of adverse consequences), a neuroimaging study demonstrated deficient ability in evaluating tradeoffs between delayed reward from abstinence from Internet Gaming and immediate satisfaction from persistent online gaming, and the impaired ability in impulse inhibition, which may be associated with the dysfunction of the prefrontal activation in the brain [Wang *et al.*, 2017]. This recent study in neuroeconomics of addiction suggests that neuroeconomic investigations into addictions to cyber-technologies are important.

As stated earlier, recent technological innovations developed Ecological Momentum Assessment methodology with CAT technique. One of the promising directions is that real-time and simultaneous measurements of economic parameters related to addictions and other health problem behaviors (e.g., time-discount rates) and biometric parameters such as stress levels and heart rates for monitoring the risks of the initiation of illicit drug use and relapse in potentially risky populations. Accumulated findings in health economics and behavioral economics may help analysis of these issues in terms of cost-effectiveness and social welfare.

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