Computational Modeling An Effective Approach to Behavioral Analysis of Addiction

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There exist different methods of cognizing a phenomenon. "Modeling" among all the methods, is a process in which the modeler attempts to represent the phenomenon in a specific form by bringing forward some aspects at the cost of others. As an example, this is the same that the German mathematician and astronomer, Johannes Kepler did when he represented the laws of movement of planets in mathematical equations by some drastic simplifications such as assuming a planet as a spaceless point. This type of modeling that employs mathematical equations to describe reality is called "Computational Modeling".

Using this modeling approach to analyze cognitive processes is known as "Cognitive Modeling" which has attracted much interest during the last two decades. Briefly put, cognitive modeling is the use of computers to model cognitive behaviors and processes.

Computational modeling offers many advantages to the field of cognitive science. Some of them can be mentioned as high description accuracy in compare to verbal modeling, feasibility of computer simulation of the model, feasibility of quantitative comparison between different models and capability of complex analyses. In addition to these advantages, quantitative observations in behavioral sciences and structural findings in neuroscience have provided appropriate substrate for this type of models.

The process of cognitive modeling starts from propounding a hypothesis about the mechanism of a specific cognitive operation in mathematical notations. In the next step the model should be assessed by comparing it with behavioral and structural data. This means the behavior of the model which is the outcome of a computer simulation is compared with the recorded data of the respective cognitive operation. The result of assessment shows the quality of the model. If the model was credible enough, it can be used for prediction and other applications.

Employing cognitive modeling to study addiction is a new viewpoint that tries to overcome the complexity of this phenomenon via a systematic approach. From a micro perspective, addiction can be analyzed in two frameworks. In the first one, the behaviors related to addictive substances (e.g., craving and relapse) are directly studied. The research plan in this area is to propound a model for normal functioning of brain and study the effect of addictive substances on it. Behaviors of addicts will be explained based on this effect. Combining a conditioning model with dopamine theory of addiction that can credibly predict the behavior of cocaine addicts can be mentioned as an example of this framework.

The second framework tries to study cognitive abilities of addicts, using the data from cognitive assessment tests. One of the cognitive abilities of addicts that has been typically assessed and modeled is addicts' ability to decide in risky situations. At the first step of modeling process in this framework, addicts cognitive abilities are assessed through some tasks. The tasks are designed to be as similar to daily life decision making circumstances as possible. The behavior of addicts in the tests will be recorded to be used in the model. The model can be selected among theories of learning, memory or decision making where the majority of these theories have come into the domain of cognitive modeling from artificial intelligence. When the modeling process is finished, the results can be used to discover the reason of decision making inabilities in addicts, comparing the mechanism of decision making of addict with those of healthy people and also to predict addicts' behavior. In addition, the model may be utilized in other related fields like behavioral economics, neuroeconomics and macro models of addiction.

"Cognitive Assessment Laboratory" of "Iranian National Center of Addictive Studies" in cooperation with "Center of Excellence for Control and Intelligent Processing of Tehran University" has started some efforts to analyze and model cognitive abilities of addicts. Cognitive assessment is often done via "Iowa Gambling Test", "Balloon Analog Risk Task", "Time Perception Test" or questionnaire. The goal of this project is to study the validity of the mentioned tests in accordance to decision making process, study the cause of decision making malfunctions and finally, integrating and uniting theories of addiction in a mathematical model.

From a micro point of view, some uses of this model can be mentioned as below:

1. Study the effect of different treatment methods via cognitive assessment of addicts in each stage of treatment and evaluating different treatment scenarios.

2. Categorizing addicts to some groups, based on cognitive properties, and evaluating different treatment methods in each group.

3. Predicting addicts' behavior. The main advantage of this prediction reveals when applied in macro analysis of addiction which is addressed below.

Using mathematical models of addiction is not confined to micro models. Each understanding of addiction entails its specific public policy. Although the goal of all these policies and interventions is to exert economic and legal laws with the aim of prevention, harm reduction and treatment, being involved in several socio-economic factors has made many complexities and difficulties in analyzing and policy making.

Economic models of addiction have reached considerable successes and there is a significant tendency toward more complete simulations with multi-agent systems' approach recently. From a macro perspective, some uses of these models can be mentioned as below:

1. Extensive computer simulations of addiction as a social rather than individual phenomenon. Drug market simulation in Melbourne is an example of such simulations. These simulations can be used to control and restrain the outbreak of an addictive substance.

2. Simulation and prediction of the result of running a specific public policy plan. For example, considering whether increasing the cigarette tariff will increase or decrease the rate of consumption of cigarette as an addictive substance.

3. Providing a useful tool for decision support. Forecasting the result of proposed policies via simulation can help policy makers to reach their objectives.

To make these models operational it seems to be necessary to have an understanding of addiction in the individual level, accessing to valid data and finally having a multi-disciplinary approach in research.

Conclusion

Drug abuse and addiction are among the most serious and costly problems facing our personal and social life. Developing computational models at all levels of analysis from macro level economic and behavioral models through micro level cognitive models gains additional insight into neurobiological, cognitive and behavioral processes underlying addiction. For this purpose, formation of multi-disciplinary research programs to facilitate development of micro-macro models seems to be a practical solution.