Author(s): Lamy, F. ; Bossomaier, T.R. ; Perez, P.

Title: SimUse: Modeling recreational polydrug through an agent-based model

Conference: International Conference on Modeling and Applied Simulation (MAS)

Location: Athens, Greece **Date:** 23-25 September, 2013

Year: 2013 **Pages:** 61 - 68

Editor:

Publisher: Caltek S.R.L

Place of Publication: Athens, Greece

Abstract: This on-going project aims to build an ontological model concerning recreational poly-drug use and to use an agent-based simulation, SimUse, to test and verify related public policies. We consider drug-use (and even more so poly-drug use) to be a complex adaptive system that needs to be studied via a methodology able to describe such a dynamic and complex social phenomenon. To contextualize the complexity of poly-drug use and highlight the necessity of a multidisciplinary approach to study this ...

SimUse: Modeling Recreational Polydrug Use through an Agent-based Model

François Lamy
CRiCS, Charles Sturt University
Clersé, Université de Lille 1
HEMA Consulting/DPMP
Bathurst/ Lille
flamy1978@gmail.com

Terry Bossomaier
CRiCS, Charles Sturt University
Bathurst
terry.bossomaier@csu.edu.au

Pascal Perez
SMART Infrastructure Facility
University of Wollongong
HEMA Consulting/DPMP
Wollongong
pascal.perez@uow.edu.au

For approximately twenty years, the drug market context has been characterized by the endemic presence of classic illicit drugs (cannabis, cocaine, MDMA[1], heroin, amphetamine-type) [1], associated with the constant appearance of new psychoactive substances (known as "designer drugs" or "legal high"), and the augmentation of pharmaceutical substance misuse [2]. This particular context, combined with the 'normalization' of drug use [3-4] has favored polysubstance use [5], in which people use more than one drug, sometimes concurrently. Polysubstance use is considered by the EMCDDA[2], as the actual "dominant pattern of drug use" and a major social issue due to increased hazard risks and health-related harms [6].

Most of the studies concerning polysubstance consumption are focused either on *simultaneous* polydrug use (SPU) as a social practice common to particular subpopulations (especially related to nightlife and rave groups) or on the adverse health effects of *concurrent* (life-based) polysubstance use (CPU) [7]. This research suggests that SPU and CPU are interdependent. This assertion is based on the fact that any drug(s) session could impact and transform representations attached by individuals to substances, and that the *drug career,* understood as the consolidated biographical experiences of polyusers, constitutes the basis that orients further decisions related to substances use. This project, therefore, studies these interconnected forms of polyuse by combining concepts coming from neuroscience (to capture the behavioral changes during SPU) to findings produces by a sociological investigation (to apprehend the changes that occurs throughout CPU). The former is informed by the literature on the subject [8-9-10] and the latter by qualitative interviews conducted during fieldwork.

An agent-based social simulation, **SimUse**, has been developed in NetLogo 4.1.3 [11]. Social simulations enable us to carry out artificial social experiments to investigate the consequences of pre-defined conditions on a range of specific social and environmental conditions. Computer simulation models have attracted an increasing number of social scientists over the last decade and have already been employed in several research for studying drug use [12-13-14]. SimUse investigates how agents can consume recreational

[1] 3-4 methylenedioxy-*N*-methylamphetamine (MDMA) is the main molecule contained in ecstasy.
[2] European Monitoring Centre for Drugs and Drug Addiction.

drugs, interact and (a) evaluate their own actions and/or (b) judge the behaviors of other agents. By doing so, SimUse assesses the impact of these drug practices on their social life. To do so, the agents representing recreational polydrug are characterized by neurological, behavioral and social attributes. These attributes generate the agents' choices, actions and interactions, informed by the qualitative interviews findings. These agents act in a preprogrammed routine inside a drastic simplification of an urban environment aggregating specific settings (Bar, Club, Bottle-Shop, etc). Other types of agents were included in the simulation (i.e, drug vendors, wholesalers and law enforcement) to recreate the context the in which the polyusers evolve.

This paper presents the three levels of modeling in SimUse: (1) the decision process for the choice of substances; (2) the neurological engine representing the behavioral and physiological responses to the consumption of the chosen substances; and (3), the intra- and extra-individual re-evalutation process following consumption.

Prior work and analysis of the interviews, carried out in Australia and France, it appears that the decisional process regarding drug use is comparable to "practical reasoning" [15]. Indeed, the interviews reveal, consistently with other research [16-17], that polydrug users have expectations regarding their consumption and infer "functions" and roles to the different substances they consume. These "functions" could be regrouped into four meaningful categories, namely "Sociable", "Relax", "Energy", and "Intoxicate". In brief, drugs providing the "Sociable" function are considered by interviewees as facilitating the communication with others and increase "fun" with peers. Substances with the "Relax" function attached to them are used for their analgesic or sedative properties and to establish a boundary between working and leisure time. "Energy" drugs are consumed for their stimulant effects allowing their users to stay awake longer and boost their physical capacities. Users that target the "Intoxicate" function generally cited drugs that produce intense rushes, hallucinations or analgesia.

Comparing findings from the qualitative interviews to the neuro-pharmacology of each drug suggests that the recreational polyuser's choices of substances are consistent with the function they target. In other words, psychoactive substances, through their actions on the different neurotransmitter systems, are means employed by polyusers to obtain particular physiological and/or psychological effects and, in turn, achieve specific functions. Table 1 lists the substances considered, together with their related functions and the neurotransmitters, which are activated by each drug.

Substance	Function	Neurotransmitters
Alcohol	Sociable	Dopamine ∇ + Serotonin ∇
	Relax	GABA ∇ + OpioidPeptide ∇ + Glutamate ©
	Intoxicate	GABA ∇ + OpioidPeptide ∇ + Glutamate ©
Cannabis	Sociable	Dopamine ∇ + Serotonin ∇
	Relax	GABA ∇ + Cannabinoid ∇
	Intoxicate	GABA ∇
Cocaine	Sociable	Dopamine ∇ + Serotonin ∇
	Energy	Norepinephrine ∇ + Glutamate ∇

Cocaine or crack	Intoxicate	Dopamine ∇
MDMA-type	Sociable	Dopamine ∇ + Serotonin ∇
	Energy	Norepinephrine ∇ + Glutamate ∇
Opiate-type	Relax	OpioidPeptide ∇
	Intoxicate	OpioidPeptid ∇ + Dopamine ∇
Amphetamine-type	Energy	Norepinephrine ∇ + Glutamate ∇
Hallucinogens	Intoxicate	Serotonin ∇

Table 1. Psychoactive substances with the different functions

By impacting specific neurotransmitter receptors, each drug induces a series of behavioral changes embedded in the "Behaviors" attribute of the user class.

Nevertheless, the decision process does not stop at the choice of substances based on their expected effects. The interviews showed that the representations users have of drugs conditions their choices. Therefore, the interviews investigated these representations and their transformations taking into account that representations are socially constructed. These "Social representations" constitute the stock of information, beliefs and opinions that actors have produced about precise objects through their experiences and interactions [18-19]. In SimUse, these social representations are modeled and formalized through numerical values representing the type of user attitudes towards each drug. The range of values goes from -5 to 5: a drug with a negative social representations will not be selected by the agent; neutral representation (0) could lead to consumption if the peers of the agent have a global positive representation of the drug; and a positive representation entail the selection of the related substance. This decisional process is modeled in SimUse as shown in figure 1:

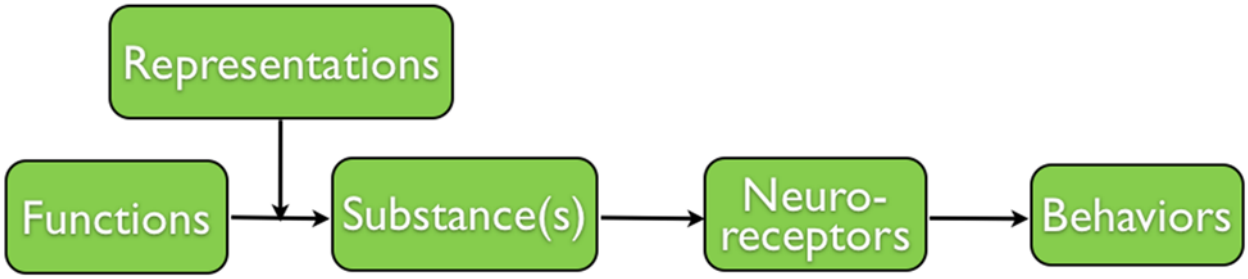
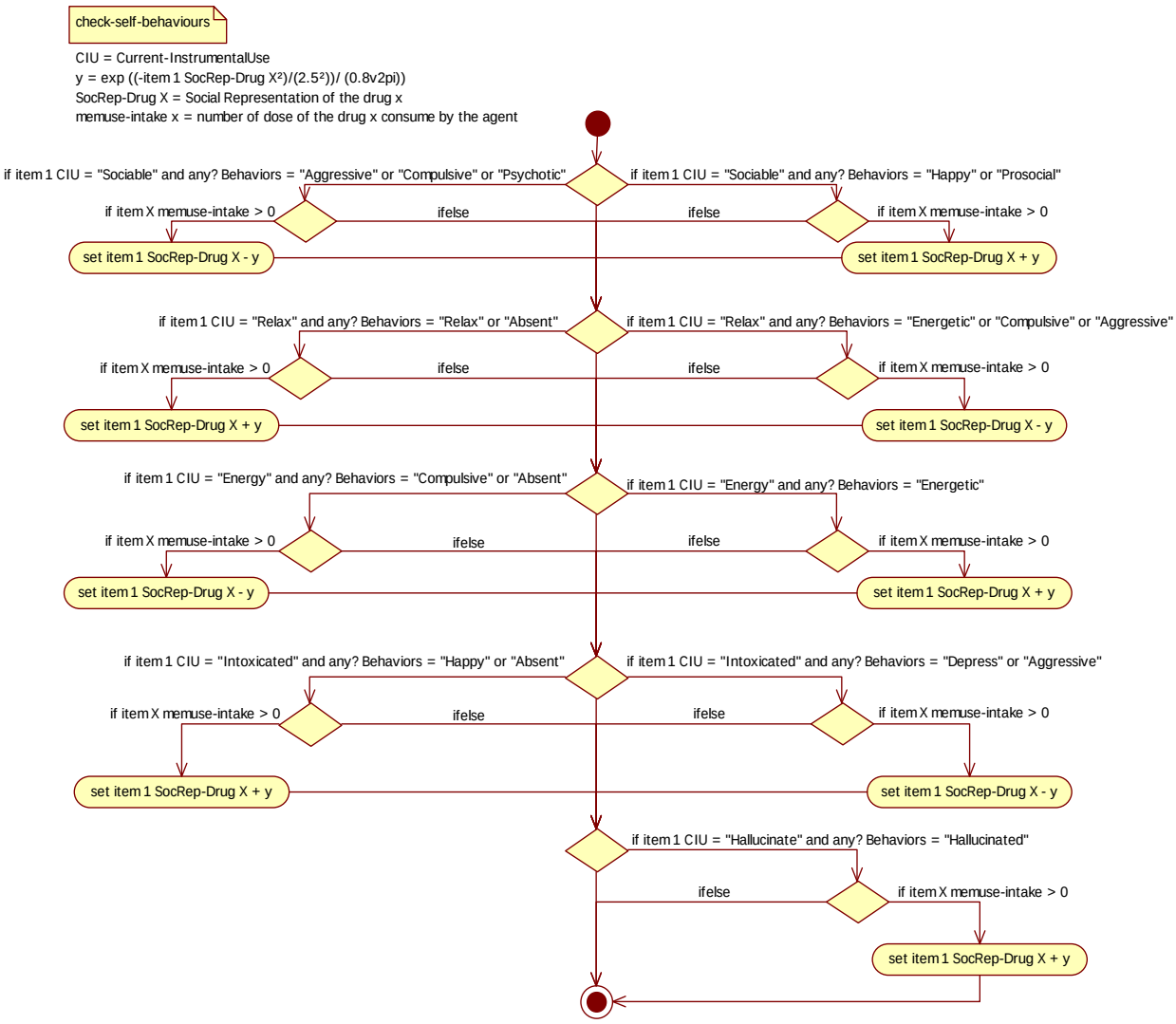


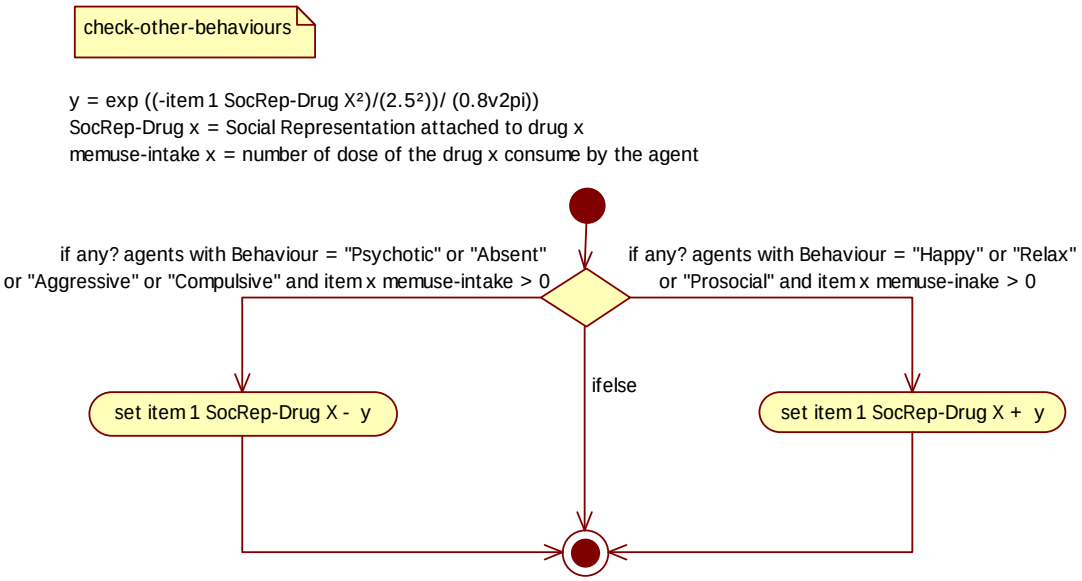
Figure 1. SimUse Drug Decisional Process

In the interviews, the respondents explained that their representations tend to be modified based on the behaviors they observe on themselves retrospectively and by judging the behaviors of other consumers. Indeed, the respondents tend to indicate that they "measure" and balance the positive and negative effects substances had on them. Positive and expected effects appear to reinforce positively the social representation users have attached to the substances (for example, becoming energetic and alert after the intentional consumption of amphetamine). Conversely, side effects and inappropriate behaviors entail a negative re-evaluation of the representation (for example, displaying aggressive behavior after the consumption of amphetamine), which in turn affects future drug-based decisions. The figure 2 provides a flowchart describing this process:



The y value displays in this activity diagram is the result of a Normal distribution of mean 0, of variance 1.25 with x equal to the value of the social representation attached to the drug. In other words, agents with social representation values close to the extremes (either -5 or 5) see their representations feebly modified, while agents with a neutral representation (equal to 0) change substantially the way they perceive the drug incriminated.

However, self-reevaluation is not the only process that affects social representations. Based on the Symbolic Interactionist perspective, we consider that meanings, and so representations, attached to objects are also modified throughout the interactions [20]. As indicated above, the respondents explained that their opinions on particular drugs could change if they witness inappropriate behavior from other users under the influence of these substances. Indeed, uncontrolled usage (i.e. compulsive use, being sick) and/or anti-social behaviour (e.g. aggressiveness) are negatively judged and stigmatized by recreational users. Conversely, witnessing expected effects and prosocial behaviors seems to modify positively users representations. This second re-evaluation process is modeled as follow (see figure 3):



It is important to note here that repeated consumption of similar substance induce a neurologic *tolerance*. This tolerance reduces the response intensity from the neuro-receptors: in term of consumption, the higher the tolerance, the more users will need to consume to obtain the expected effects. Increased doses generate more intense side-effects leading to inappropriate behaviors or unpleasant outcomes, modifying in turn the representation associated with the drug. Taking into account the re-evaluations processes and neurological tolerance, the decisional process shown in figure 1 is updated as follows (see Figure 4):

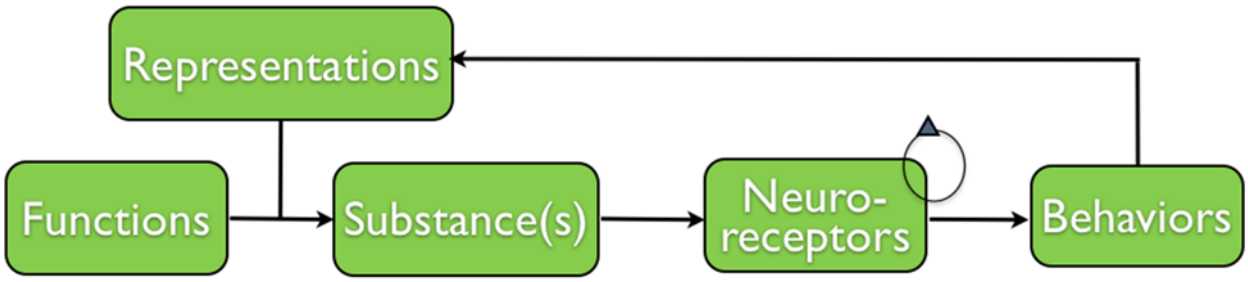


Figure 4. SimUse Iterated Decisional Process

Sample results are provided for the scenario where the availability of cannabis is drastically reduced, say, by a drug seizure. Figure 5 shows these preliminary results:

In conclusion, drug policy is a complex topic due to the large number of protective and risk factors that can influence the choices and actions of drug users. Restricting one drug may cause an increase in another as well as other unattended consequences. This paper argues in favor of the utilization of social simulation to assist decision-makers in their choices.

References:

[1] C. Faugeron & M. Kokoreff. *Société avec drogues: Enjeux et Limites*, Eres, 2002

[2] European Monitoring Centre for Drugs and Drug Addiction. *EU drug markets report: a strategic analysis*. Lisbon. 2013.

[3] H. Parker, J. Aldridge & F. Measham, *Illegal Leisure: the Normalization of Recreational Drug Use*, Routledge, 1998.

[4] H. Parker, Normalization as a barometer: Recreational drug use and the consumption of leisure by younger Britons, *Addiction Research and Theory,* 13(3), pp. 205-215. 2005

[5] A. Fontaine, C. Fontana, C. Verchère & R. Vischi, Nouvelles drogues, nouveaux usages. Evolution de la consommation de substances psychoactives en France et en Europe et particularités du milieu festif. *Revue Toxibase,* 4, 2001.

[6] European Monitoring Centre for Drugs and Drug Addiction. Polydrug use: Patterns and responses. *Annual Report*. 2009.

[7] R. Ives & P. Ghelani. Polydrug use (the use of drugs in combination): A brief overview, *Drugs: education, prevention and policy,* 13(3), pp. 225-232. 2006.

[8] R. M, Julien, C. D. Advokat & J. E. Comaty. *A primer in drug action: a comprehensive guide to the actions, uses, and side effects of psychoactive drugs*, Worth Publisher, 11th ed. 2008.

[9] G. F. Koob & M. LeMoal. *Neurobiology of Addiction,* Academic Press, Elsevier. 2006.

[10] R.L. Solomon. The opponent-process theory of acquired motivation: the costs of pleasure and the benefits of pain. *American Psychologist.* 35, pp. 691-712. 1980.

[11] http://ccl.northwestern.edu/netlogo/. U. Wilensky. NetLogo. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. 1999.

[12] M. Agar & D. Wilson. Drugmart: Heroin Epidemics as Complex Adaptive Systems, *Complexity,* vol. 7 (5). 2002.

[13] P. Perez, A. Dray, A. Ritter, P. Dietze, T. Moore & L. Mazerolle. SimDrug: Exploring the Complexity of Heroin Use in Melbourne, DPMP. Monograph 11. 2005.

[14] L. D. Hoffer, G. Bobashev R. & J. Morris. Researching a Local Heroin Market as a Complex Adaptive System, *American Journal of Community Psychology,* 44 (3-4) pp. 273-286. 2009

[15] M. E. Bratman. *Intentions, Plans and Practical Reason*. Harvard University Press, Cambridge. 1987.

[16] A. Boys et al. What Influences Young People's Use of Drugs? A qualitative study of decision-making. *Drugs: education, prevention and policy*, 6(3), pp. 373-387. 1999.

[17] A. Boys & J. Marsden. Perceived functions predict intensity of use and problems in young polysubstance users. *Addiction,* 98, pp. 951-63. 2003.

[18] D. Jodelet. *Les représentations sociales*, PUF, Paris. 2003.

[19] P. Moscovici. *Psychologie Sociale*, PUF, Paris, 2011.

[20] H. Blumer. *Symbolic Interactionism: Perspective and Method*, University of California Press, Berkeley. 1998.