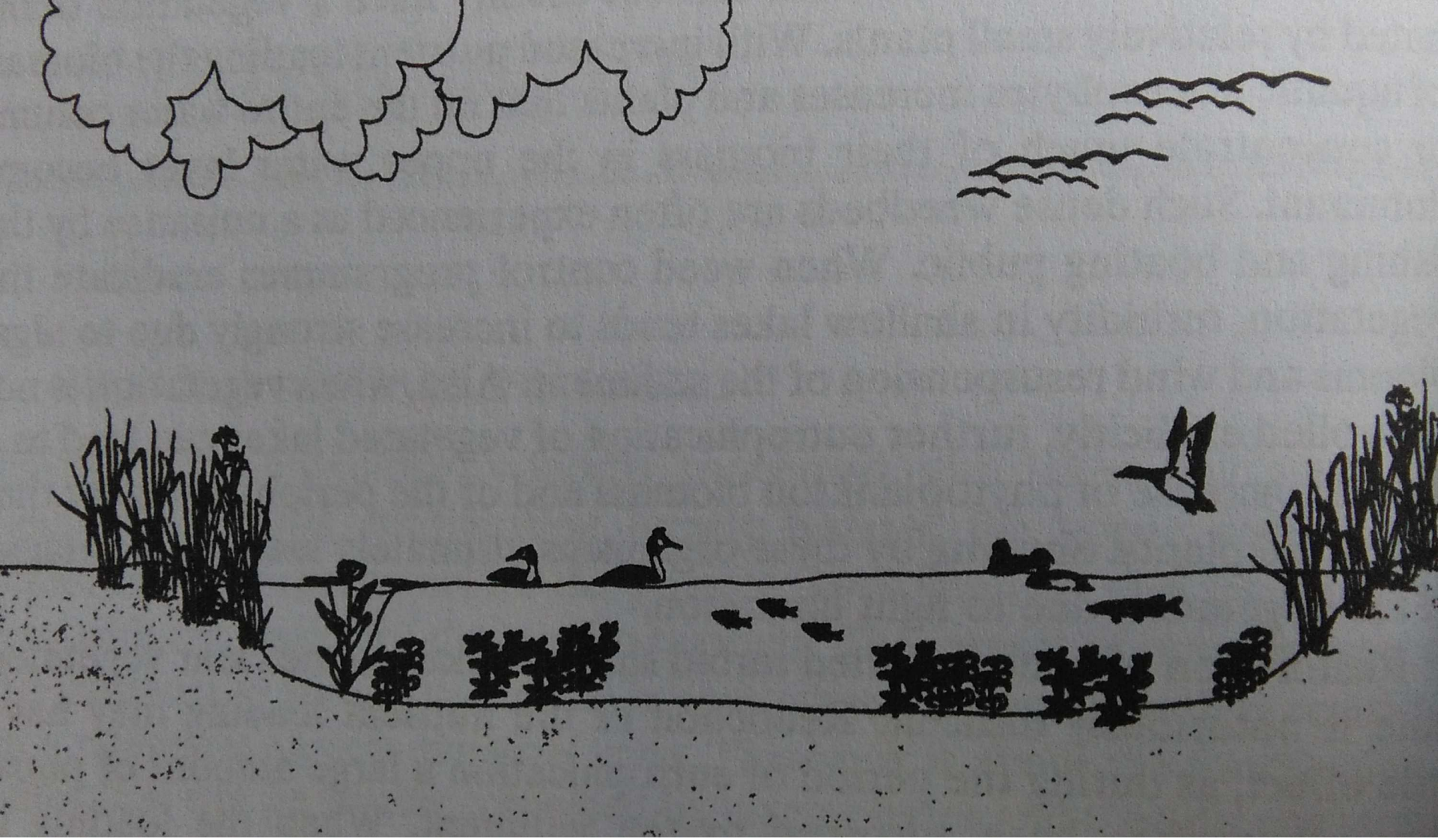
Intermediate Stable States in Substance Use

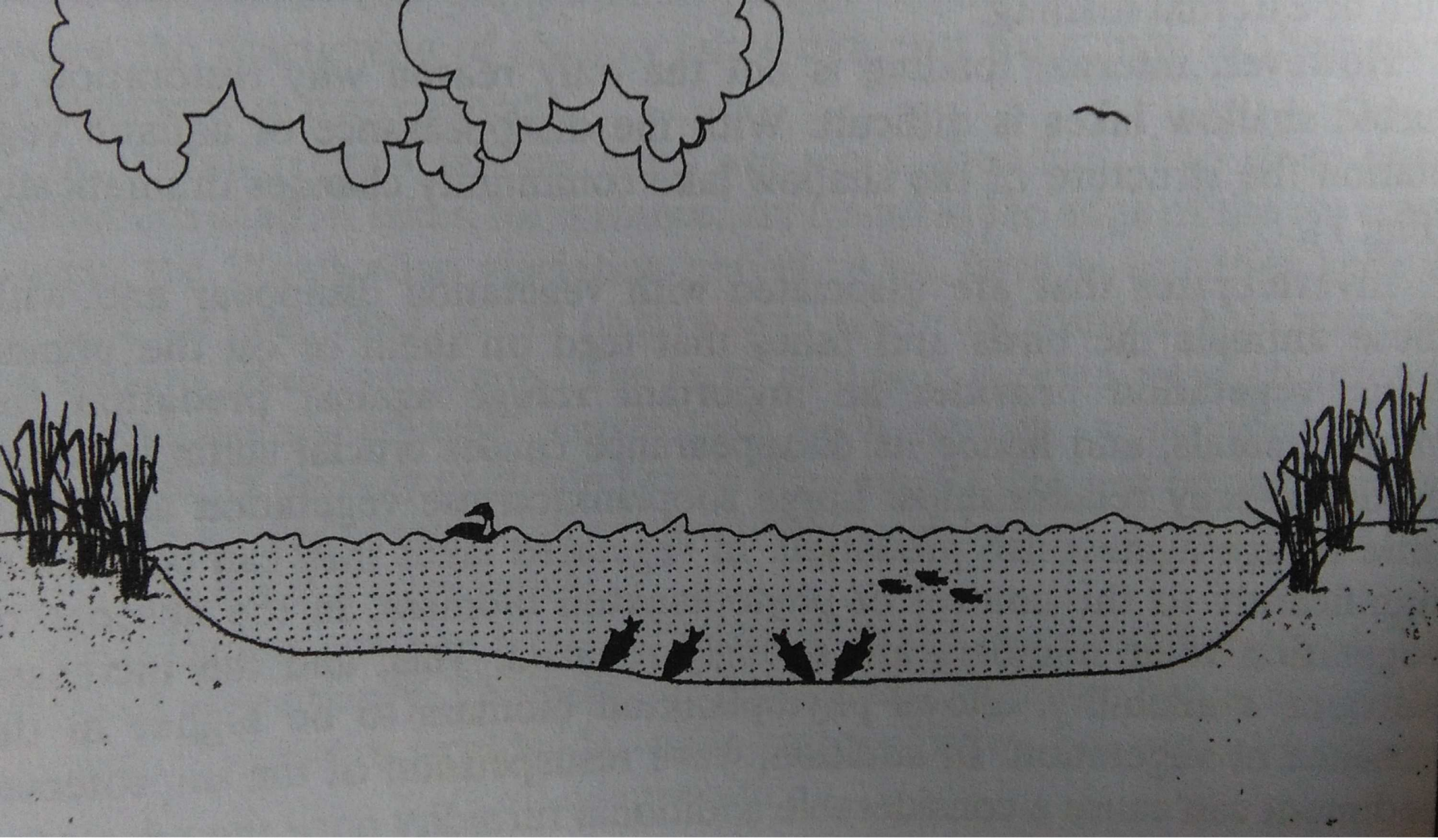
Can allowing use prevent abuse?

Sacha Epskamp – ICPS 2019

University of Amsterdam
Institute for Advanced Study



Scheffer, M. (2004). Ecology of shallow lakes. Berlin, Germany: Springer Science & Business Media.



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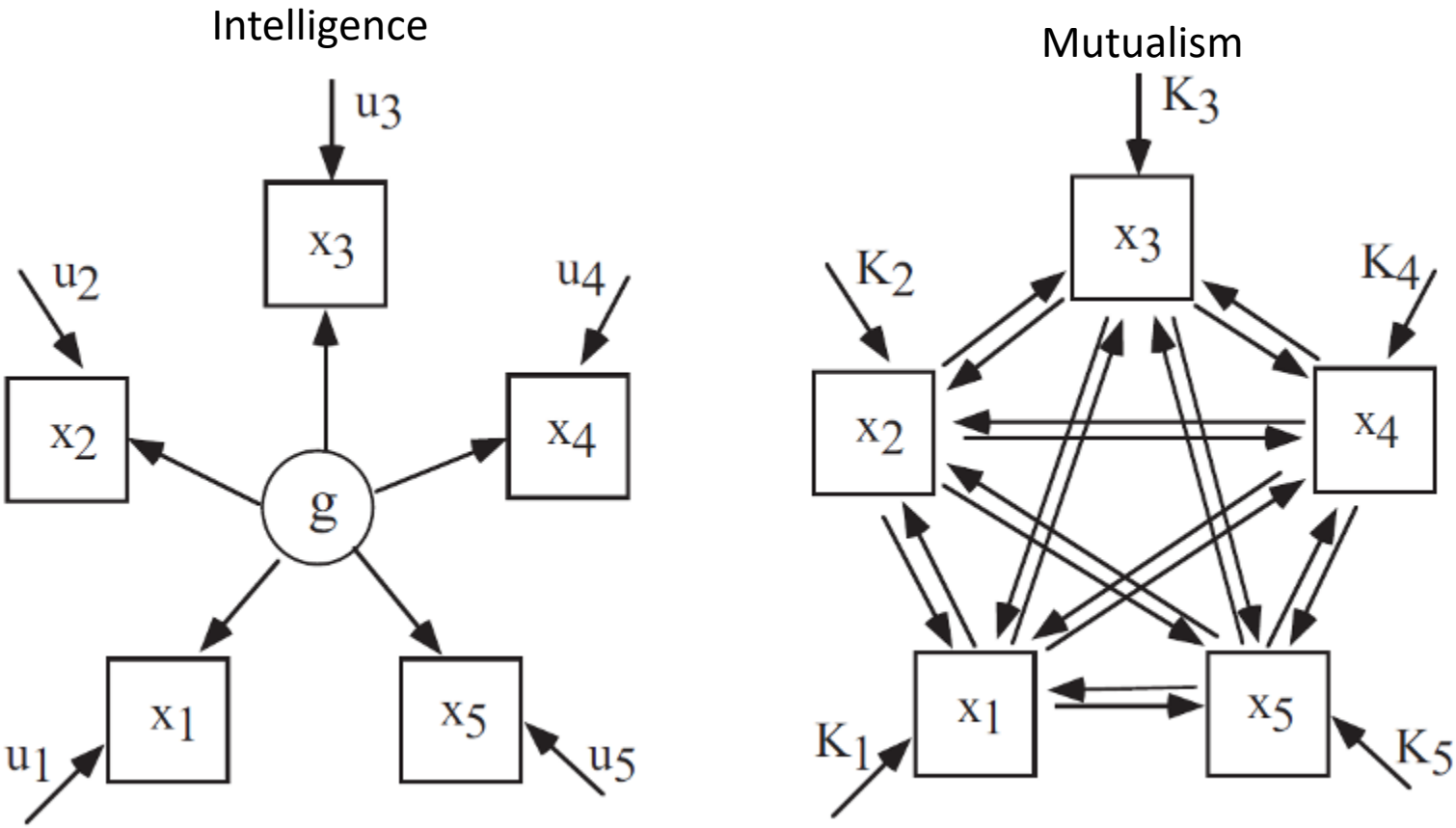

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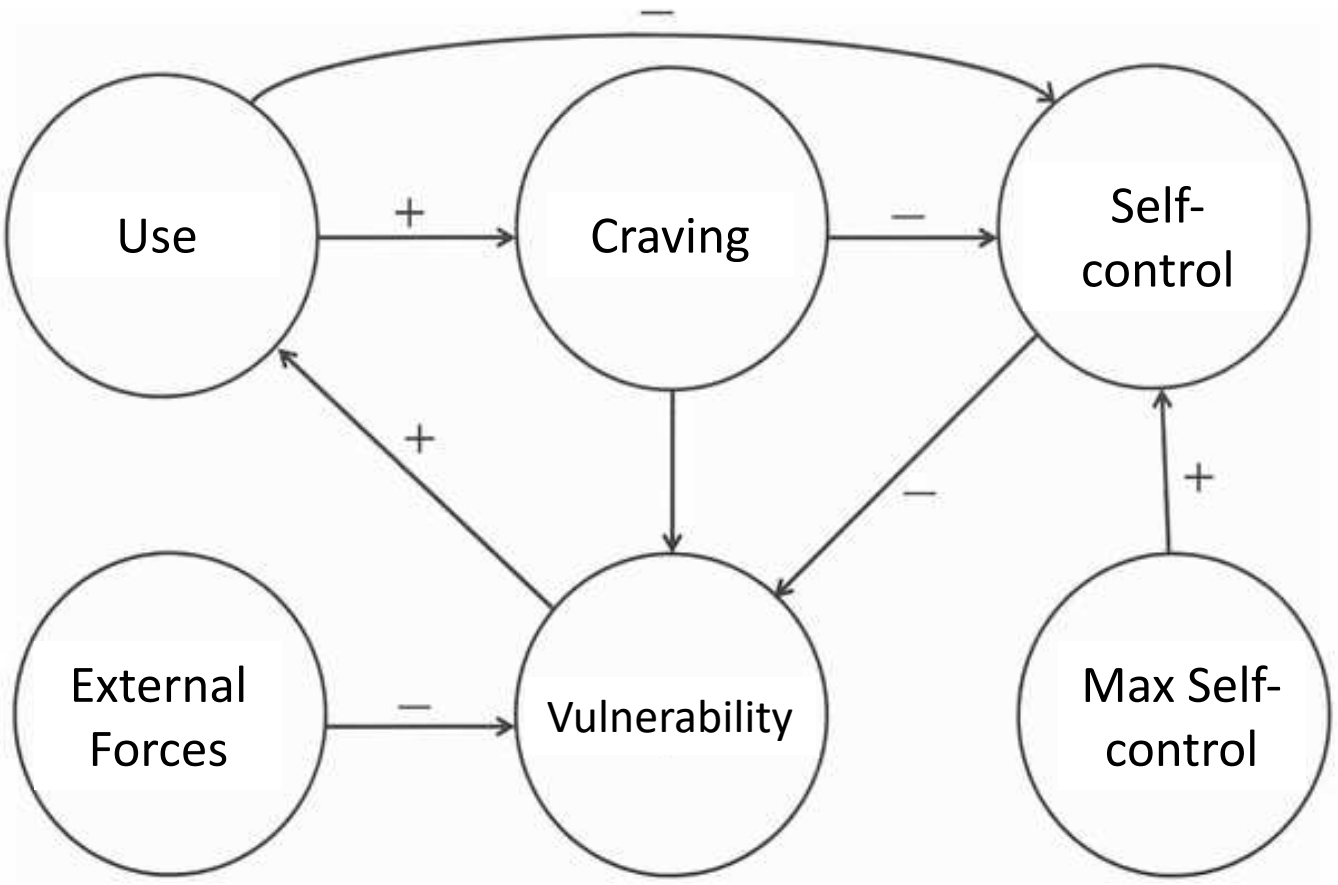
Dynamics of Substance use



Grasman J, Grasman RPPP, van der Maas HLJ (2016) The Dynamics of Addiction: Craving versus Self-Control. PLOS ONE 11(6): e0158323. https://doi.org/10.1371/journal.pone.0158323
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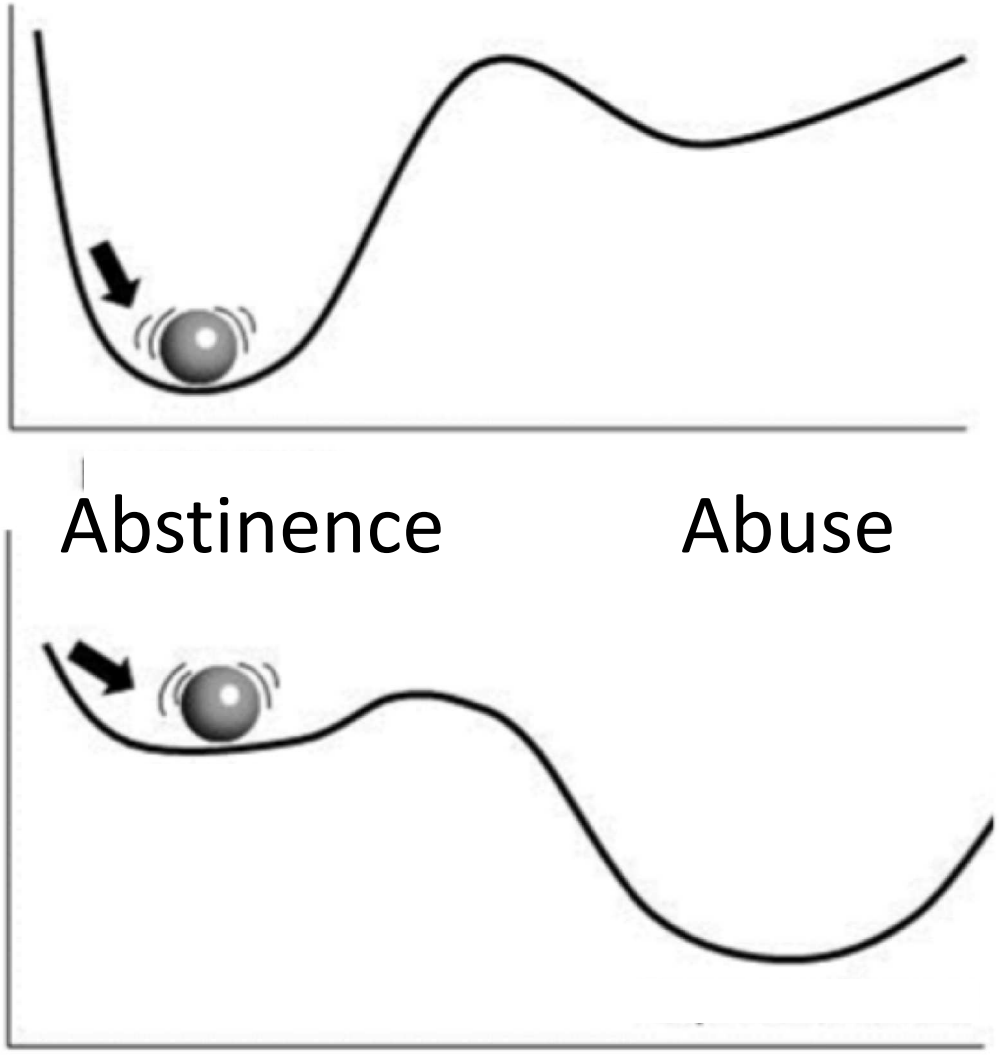
Abstinence
Abuse

Table 3. Estimated Cumulative Incidence of Drug Use by Age 15 and 21 y among 22–29 y Olds

Region	Country	Unweighted *n*	Alcohol				Tobacco				Cannabis				Cocaine			
			By 15 y		By 21 y		By 15 y		By 21 y		By 15 y		By 21 y		By 15 y		By 21 y	
			Percent	SE	Percent	SE	Percent	SE	Percent	SE	Percent	SE	Percent	SE	Percent	SE	Percent	SE
Americas	Colombia	4,426	57.4	2.3	92.2	1.2	12.3	1.3	37.5	1.9	2.9	0.6	10.2	1.2	0.8	0.3	3.1	0.8
	Mexico	5,782	29.0	1.9	77.5	1.2	21.4	1.4	52.5	1.6	2.2	0.5	8.0	1.1	0.6	0.3	4.1	0.7
	US	5,692	50.1	2.5	93.1	1.3	43.6	2.4	71.6	2.8	20.2	1.8	54.0	2.8	2.5	0.8	16.3	1.6
Europe	Belgium	1,043	67.0	8.3	88.5	6.1	—[a]	—	—[a]	—	4.7	2.5	22.2	6.6	0.0	0.0	0.6	0.4
	France	1,436	68.2	3.2	94.5	2.2	—[a]	—	—[a]	—	15.3	4.3	44.1	5.3	0.0	0.0	1.9	1.3
	Germany	1,323	82.1	3.2	97.8	1.1	—[a]	—	—[a]	—	13.0	3.3	41.0	4.8	0.0	0.0	6.1	2.7
	Italy	1,779	44.9	3.6	76.3	3.6	—[a]	—	—[a]	—	3.3	1.1	13.7	2.5	0.0	0.0	0.9	0.6
	Netherlands	1,094	59.6	7.7	89.7	6.4	—[a]	—	—[a]	—	7.0	3.0	34.6	7.1	0.0	0.0	1.0	0.6
	Spain	2,121	52.8	4.8	92.1	2.1	—[a]	—	—[a]	—	8.5	2.6	27.7	4.4	0.1	0.1	5.3	1.8
	Ukraine	1,719	39.3	3.9	98.5	1.1	46.0	4.9	72.1	3.9	1.3	0.7	12.3	2.6	—[b]	—	—[b]	—
Middle East and Africa	Israel	4,859	15.2	1.2	62.7	1.6	8.9	0.9	43.2	1.6	0.3	0.2	13.7	1.1	0.0	0.0	0.5	0.2
	Lebanon	1,031	24.3	5.2	45.8	6.5	18.0	2.8	51.1	6.4	0.4	0.3	5.7	2.7	—[b]	—	—[b]	—
	Nigeria	2,143	31.4	3.2	52.5	3.1	6.9	1.7	10.1	1.7	0.2	0.2	1.9	0.9	—[b]	—	—[b]	—
	South Africa	4,315	9.4	1.4	39.5	2.0	11.0	1.6	31.0	1.6	1.6	0.5	11.0	1.4	—[b]	—	—[b]	—
Asia	Japan	887	30.4	6.7	91.9	5.8	—[a]	—	—[a]	—	—[b]	—	—[b]	—	—[b]	—	—[b]	—
	People's Republic of China	1,628	31.7	5.1	73.6	5.2	15.2	3.7	54.7	5.0	—[b]	—	—[b]	—	—[b]	—	—[b]	—
Oceania	New Zealand	12,790	74.1	1.5	94.1	0.9	—[a]	—	—[a]	—	26.8	1.4	61.8	1.5	0.1	0.1	5.0	0.8

Data from the World Mental Health Surveys. Weighted data, Taylor series linearisation for variance estimation.
[a]Not asked in this country.
[b]Fewer than 30 persons in the entire sample of this country used this drug, so estimates have not been produced.
SE, standard error.
doi:10.1371/journal.pmed.0050141.t003

Degenhardt, L., Chiu, W. T., Sampson, N., Kessler, R. C., Anthony, J. C., Angermeyer, M., ... & Karam, A. (2008). Toward a global view of alcohol, tobacco, cannabis, and cocaine use: findings from the WHO World Mental Health Surveys. *PLoS medicine*, *5*(7), e141.

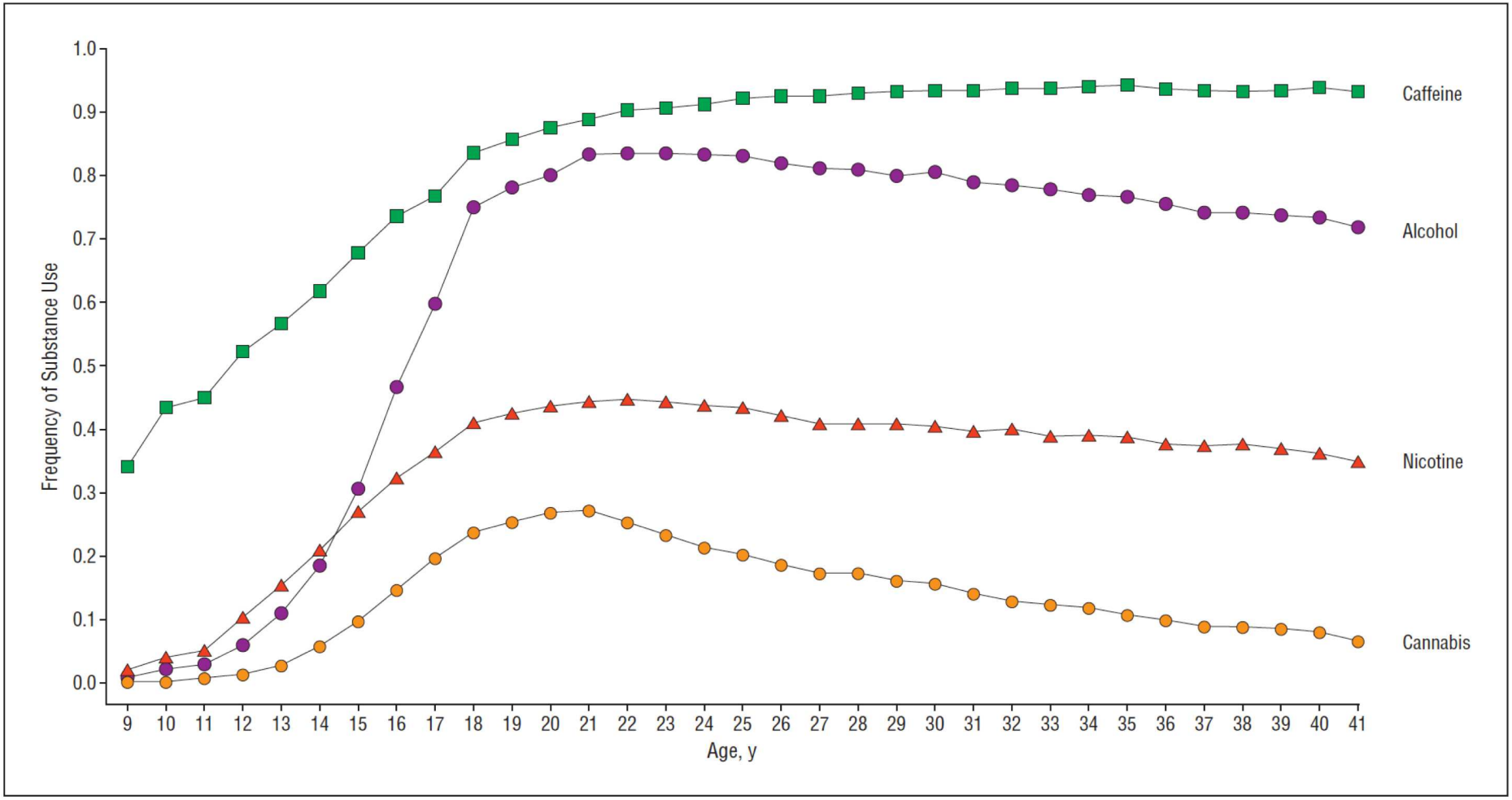

Figure 1. The frequency of any use of caffeine, alcohol, nicotine, and cannabis by year from ages 9 to 41 years.

Kendler, K. S., Schmitt, E., Aggen, S. H., & Prescott, C. A. (2008). Genetic and environmental influences on alcohol, caffeine, cannabis, and nicotine use from early adolescence to middle adulthood. *Archives of general psychiatry*, *65*(6), 674-682.

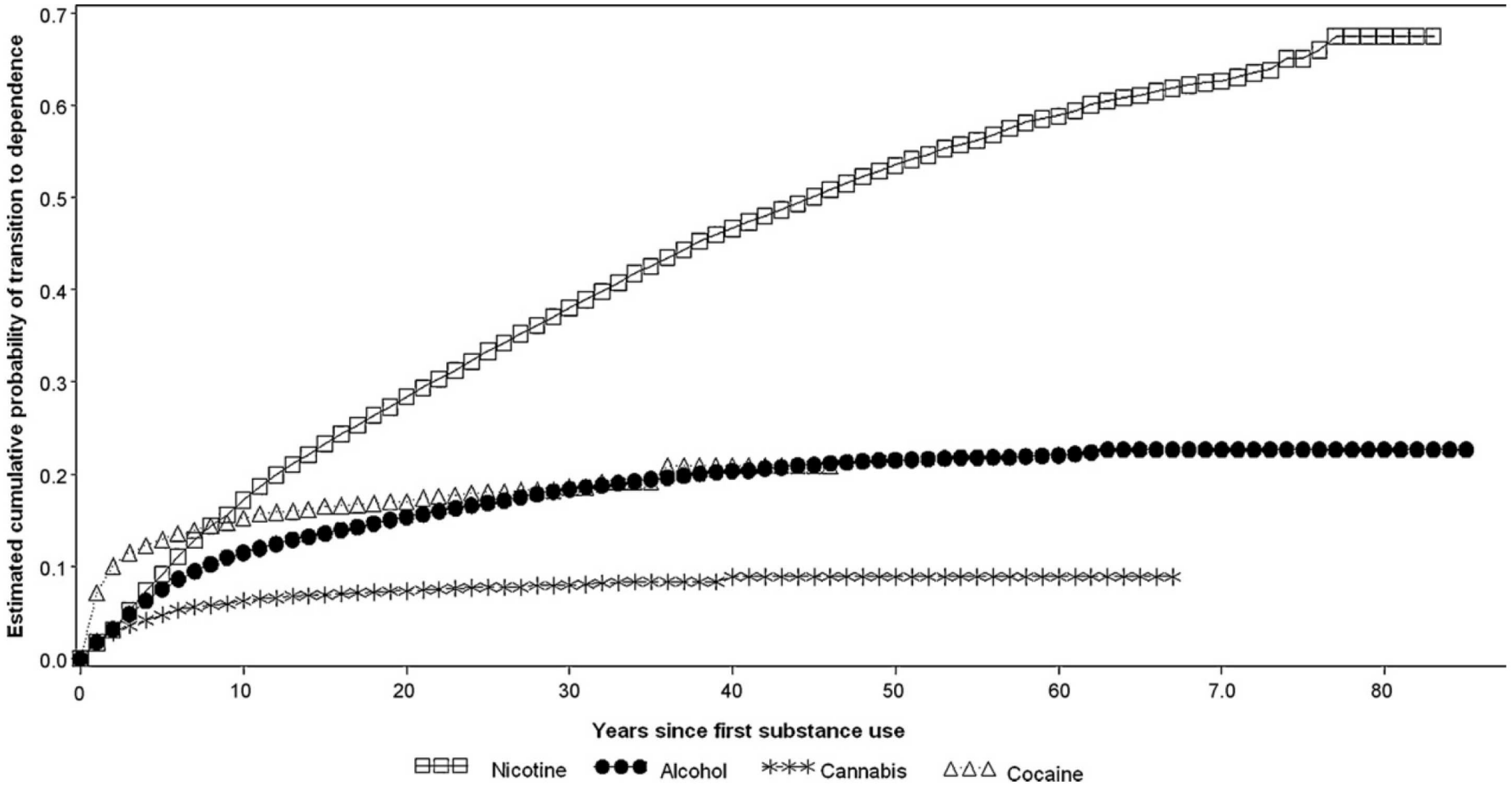

Fig. 1. Cumulative probability of transitioning to dependence on nicotine, alcohol, cannabis and cocaine among users of these substances.

Probability and predictors of transition from first use to dependence on nicotine,
alcohol, cannabis, and cocaine: Results of the National Epidemiologic Survey on
Alcohol and Related Conditions (NESARC)

Stable Intermediate states in substance use

- Previous modeling and empirical work on substance from a nonlinear dynamical system perspective models two alternative stable states: zero-use and abuse
- Many intervention and prevention strategies aim at the no use state
  - For many youth these strategies fail
- In this project, we look at possible intermediate stable states of recreational use

Work with Han van der Maas, Roseann Peterson, Hanna van Loo, Steven Aggen, Kenneth Kendler, Egbert van Nes & Marten Scheffer

Drugs as instruments: A new framework for non-addictive psychoactive drug use

Christian P. Müller [a1] [a2] and Gunter Schumann [a1]

https://doi.org/10.1017/S0140525X11000057 Published online: 10 November 2011

In response to: Drug instrumentalization and evolution: Going even further

Related commentaries (1)

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Saul Shiffman

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Careers with Heroin

Gail A. Crawford, Melvin C. Washington & Edward C. Senay

Pages 701-715 | Published online: 03 Jul 2009

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Prospective Analysis of Behavioral Economic Predictors of Stable Moderation Drinking Among Problem Drinkers Attempting Natural Recovery

Jalie A. Tucker, JeeWon Cheong, Susan D. Chandler, Brice H. Lambert, Brittney Pietrzak, Heather Kwok, and Susan L. Davies

Empirical exploration

- Empirical sample of 1796 men
- Reports on lifetime use per year on alcohol, cannabis and nicotine use
- Use classified as (1) zero-use, (2) recreational use and (3) abuse, based on literature and expert opinion
  - Alcohol abuse: > 60 drinks per month
  - Nicotine abuse: > 5 cigarettes per day
  - Cannabis abuse: > 6 times used per month
- Descriptive investigation of transition probabilities between years, and number of people who reported such transitions

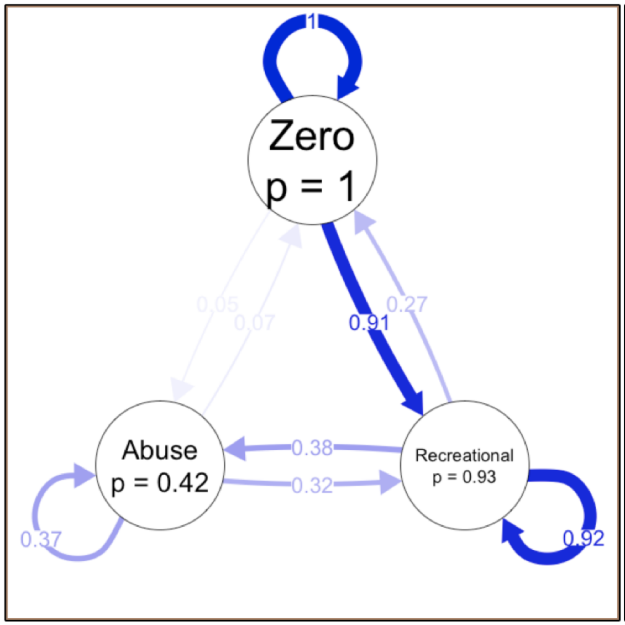
SAMPLE

This article uses data collected in the third wave of interviews in white, adult, male twins born between 1940 and 1974 from the VATSPSUD.[13] All of the subjects for the VATSPSUD were ascertained from the Virginia Twin Registry, a population-based register formed from a systematic review of birth certificates in the Commonwealth of Virginia. Response rates for the first (1993-1996) and second (1994-1998) waves of interviews were 72% and 83%, respectively. The third interview wave, restricted to male-male twins, was completed in 1998 to 2004 by 1796 male twins (75%) who had participated in the second interview, including both members of 469 MZ and 287 DZ pairs. Subjects were aged 24 to 62 years (mean [SD] age, 40.3 [9.0] years). Most subjects were interviewed by telephone. After an explanation of the research protocol, signed informed consent was obtained for face-to-face interviews and verbal consent was obtained for telephone interviews. This project was approved by the Office of Research Subjects Protection at Virginia Commonwealth University. Members of a twin pair were always interviewed by different interviewers. Zygosity was assigned by a combination of self-report measures, photographs, and DNA polymorphisms.[13]

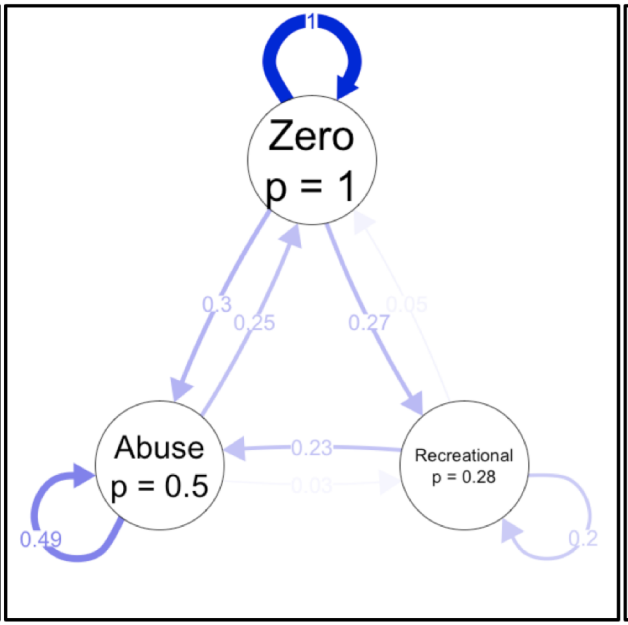
Kendler, K. S., Schmitt, E., Aggen, S. H., & Prescott, C. A. (2008). Genetic and environmental influences on alcohol, caffeine, cannabis, and nicotine use from early adolescence to middle adulthood. *Archives of general psychiatry*, *65*(6), 674-682.

Shiny app

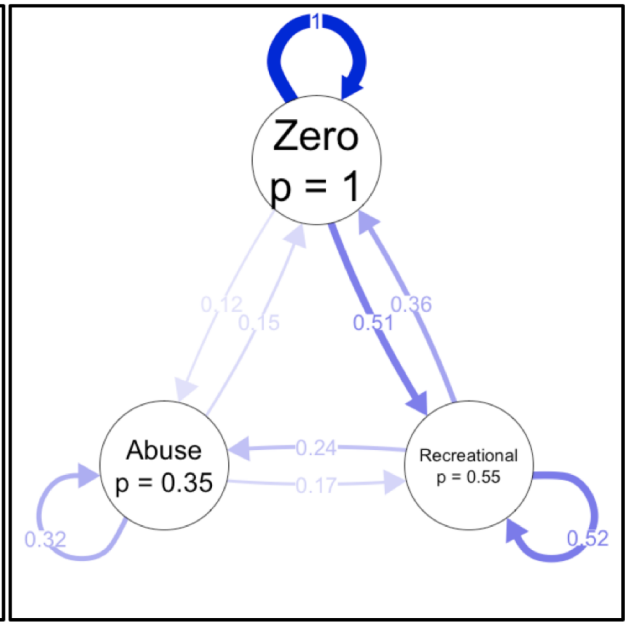
https://sachaepskamp.shinyapps.io/intermediate_stable_states/



(a) Alcohol use

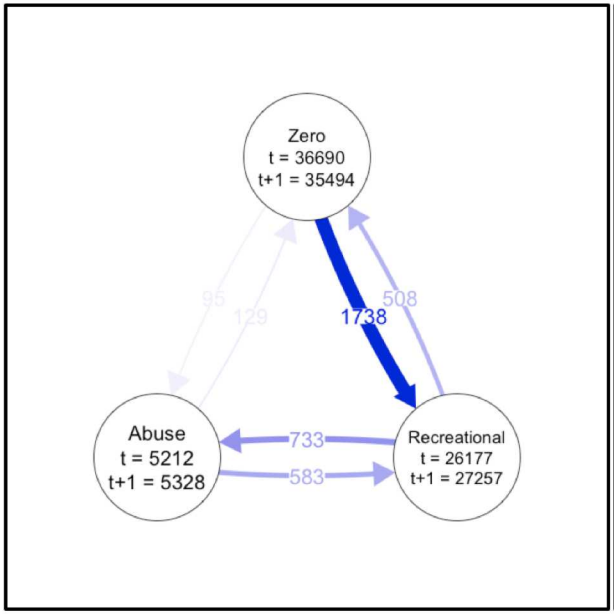


(b) Tobacco use

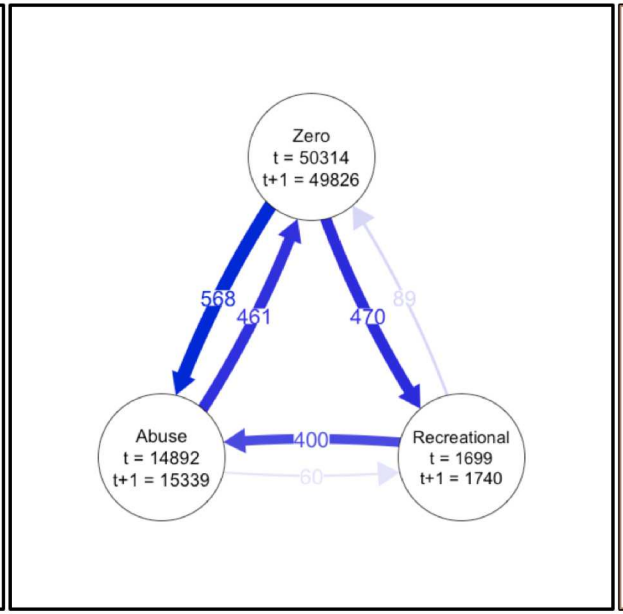


(c) Cannabis use

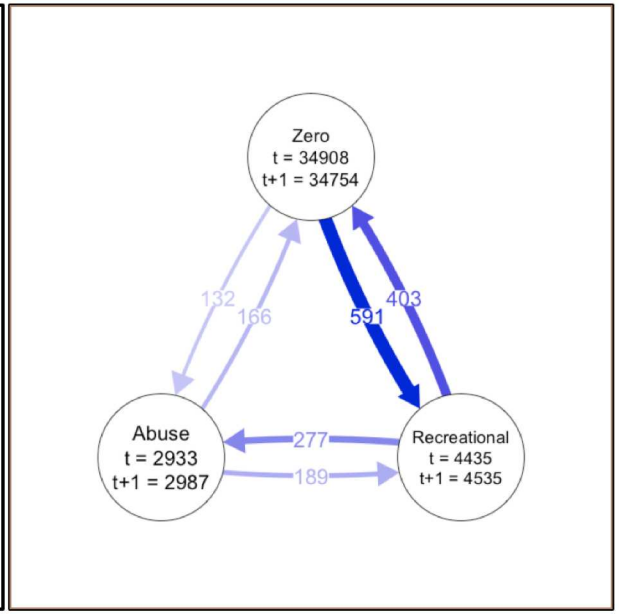
Proportion of subjects reporting at least one transition



(a) Alcohol use



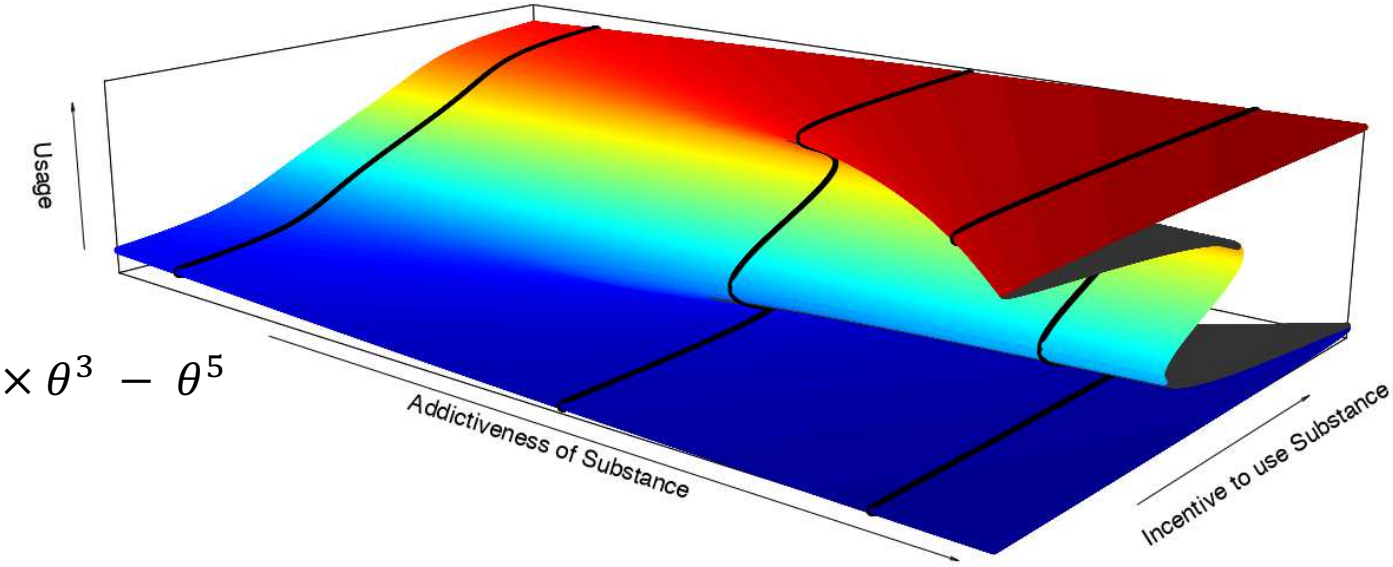
(b) Tobacco use



(c) Cannabis use

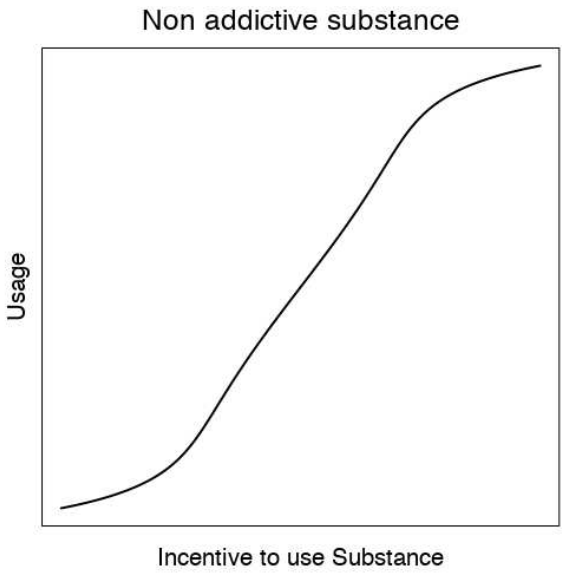
Raw number of transitions

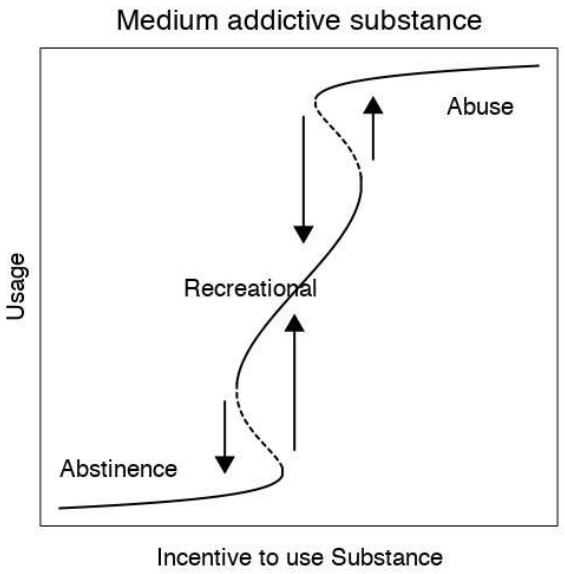
Theoretical model 1: descriptive

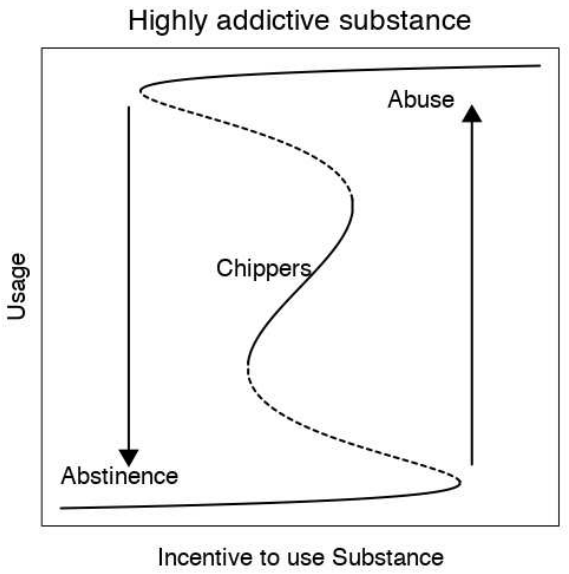


$$\frac{\partial \theta}{\partial t} = I - 10 \times \theta + A \times \theta^3 - \theta^5$$

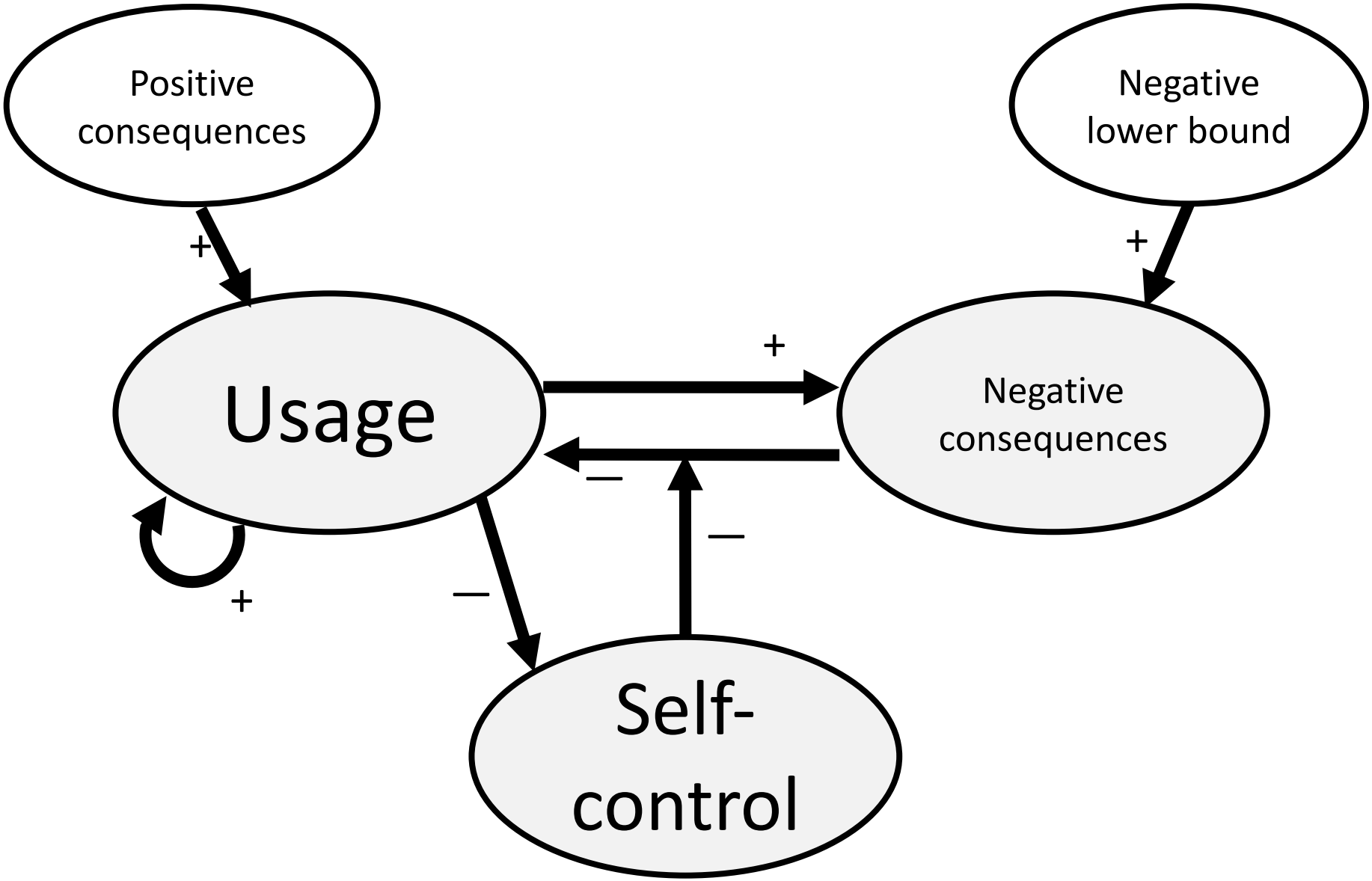
$$U = \frac{e^{\theta}}{1 + e^{\theta}}$$



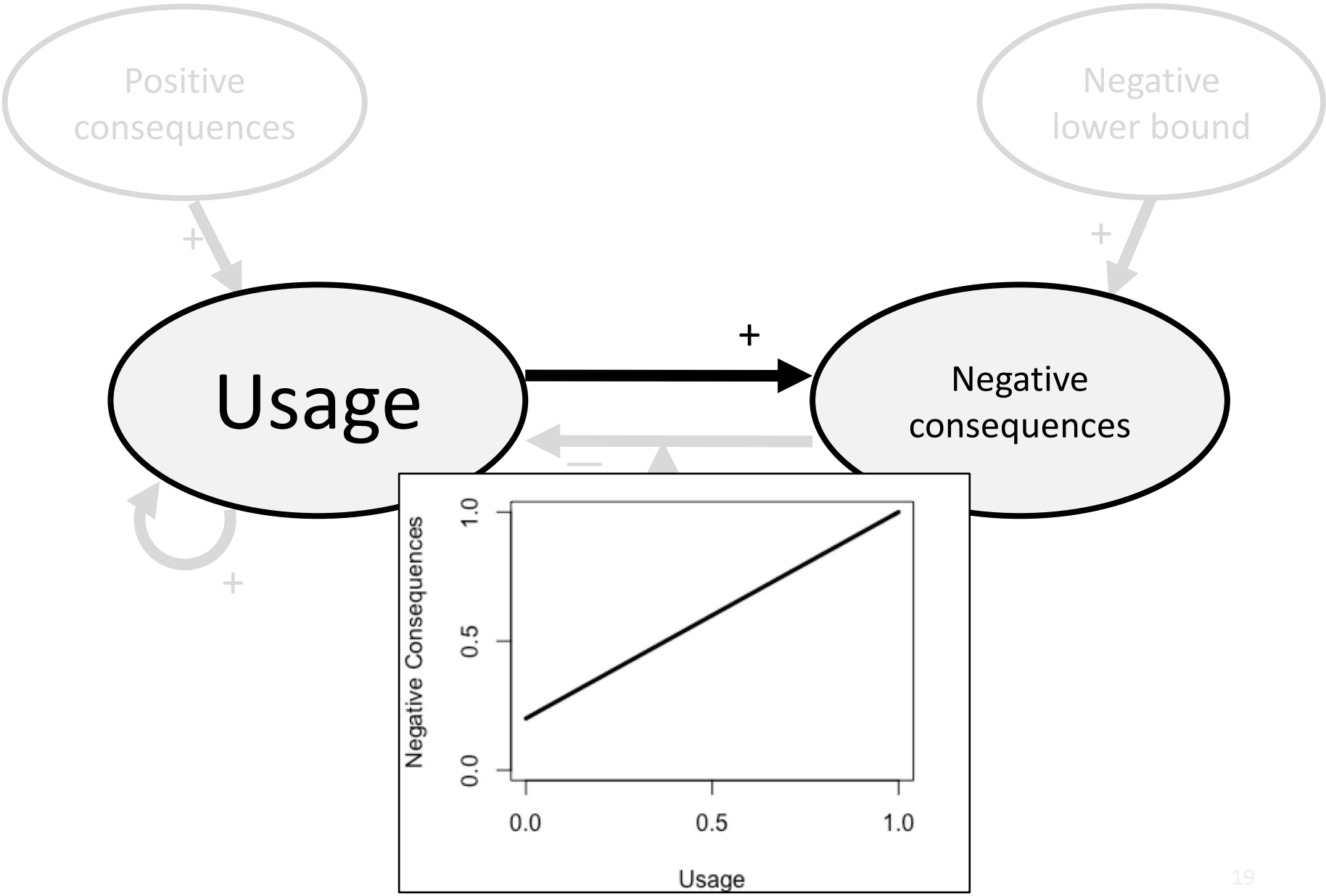




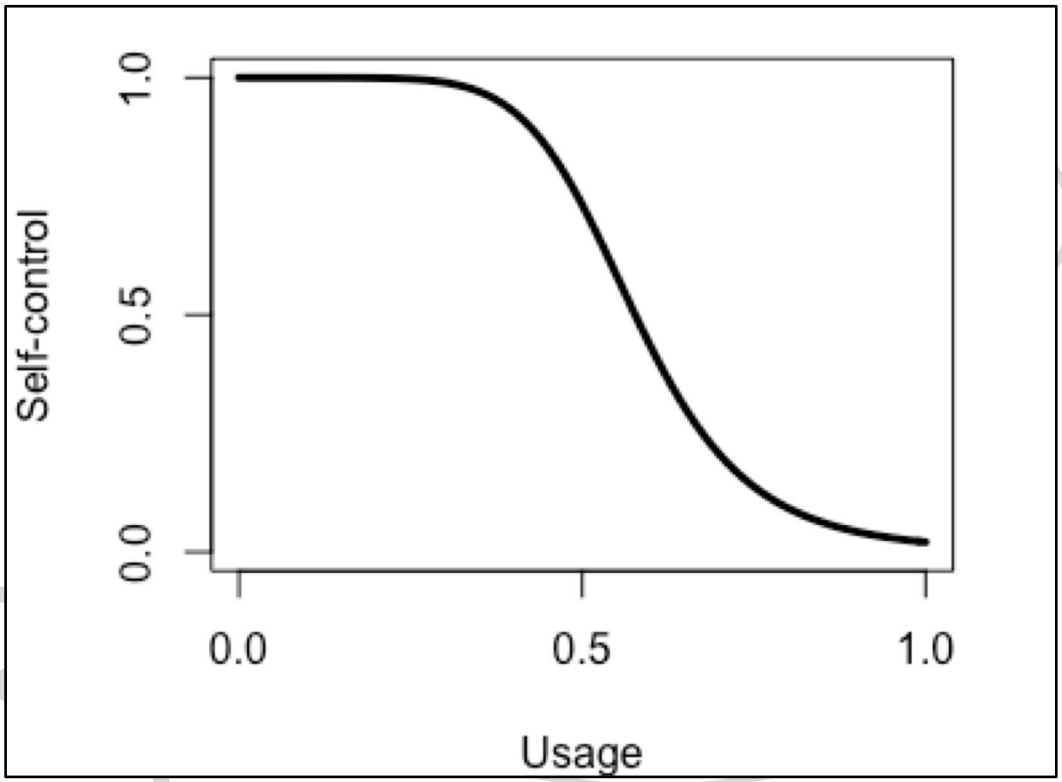
Theoretical model 2: conceptual



Theoretical model 2: conceptual



Theoretical model 2: conceptual



Positive consequences

+

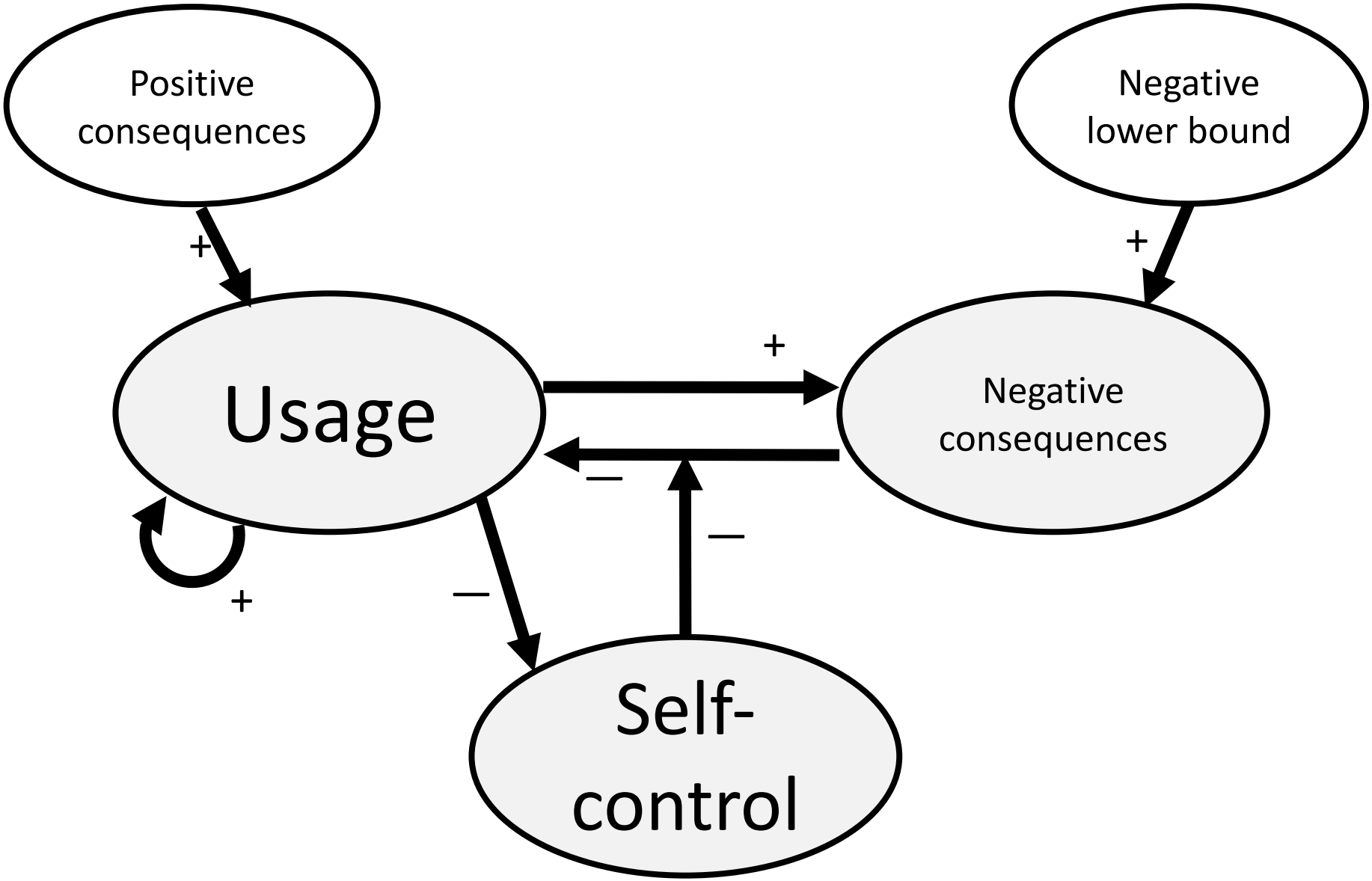
Usage

+

–

Self-control

Theoretical model 2: conceptual



Equilibrium equations:

$$N_{\text{eq}} = N_{\text{lower}} + (1 - N_{\text{lower}}) \times U^{p_n}$$

$$S_{\text{eq}} = \frac{H^{p_s}}{H^{p_s} + U^{p_s}}$$

Parameter	Explanation
U	Usage
S	Self-control
N	Negative consequences
P	Positive consequences
r_u	Rate of usage dynamics
r_s	Rate of self-control dynamics
r_n	Rate of negative consequences dynamics
A	Addictiveness / Proneness
S_{eq}	Self-control equilibrium
N_{eq}	Negative consequences equilibrium
N_{lower}	Negative consequences lower bound
p_n	Exponent
H	Point at which Self-control is 0.5
p_s	Exponent

Dynamical equations:

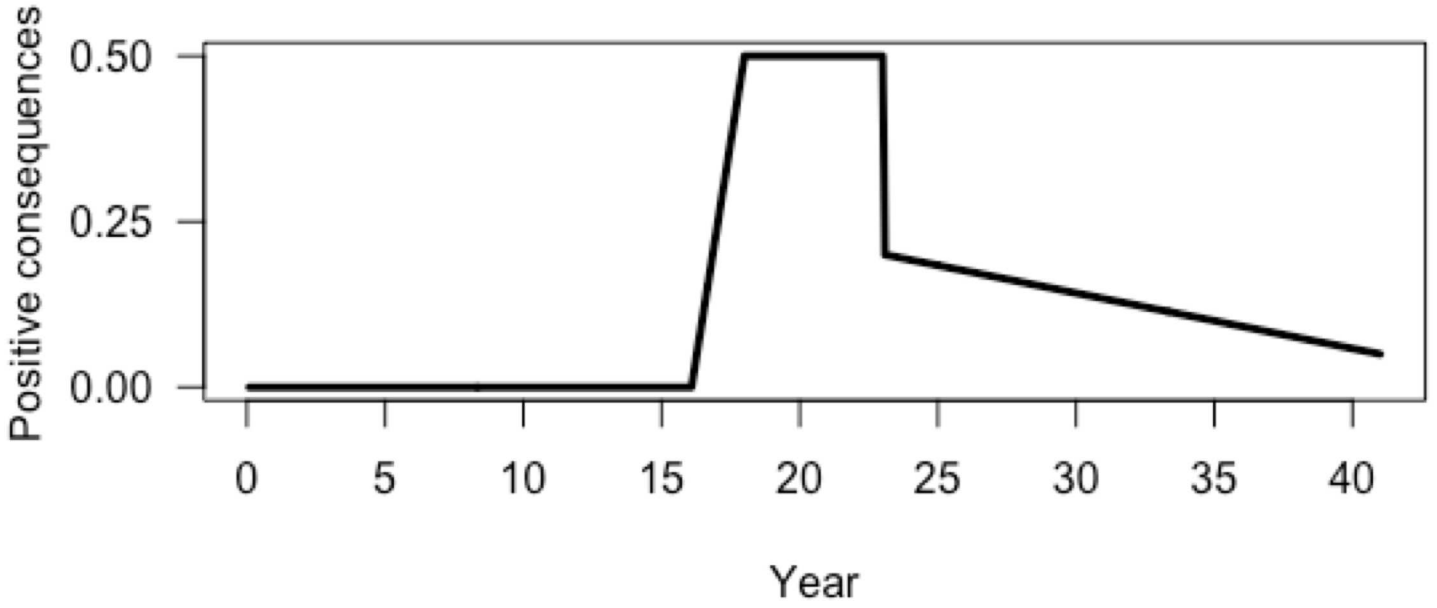
$$\frac{\partial U}{\partial t} = r_u \times U \times (1 - U) \times (P - S \times N + A \times U)$$

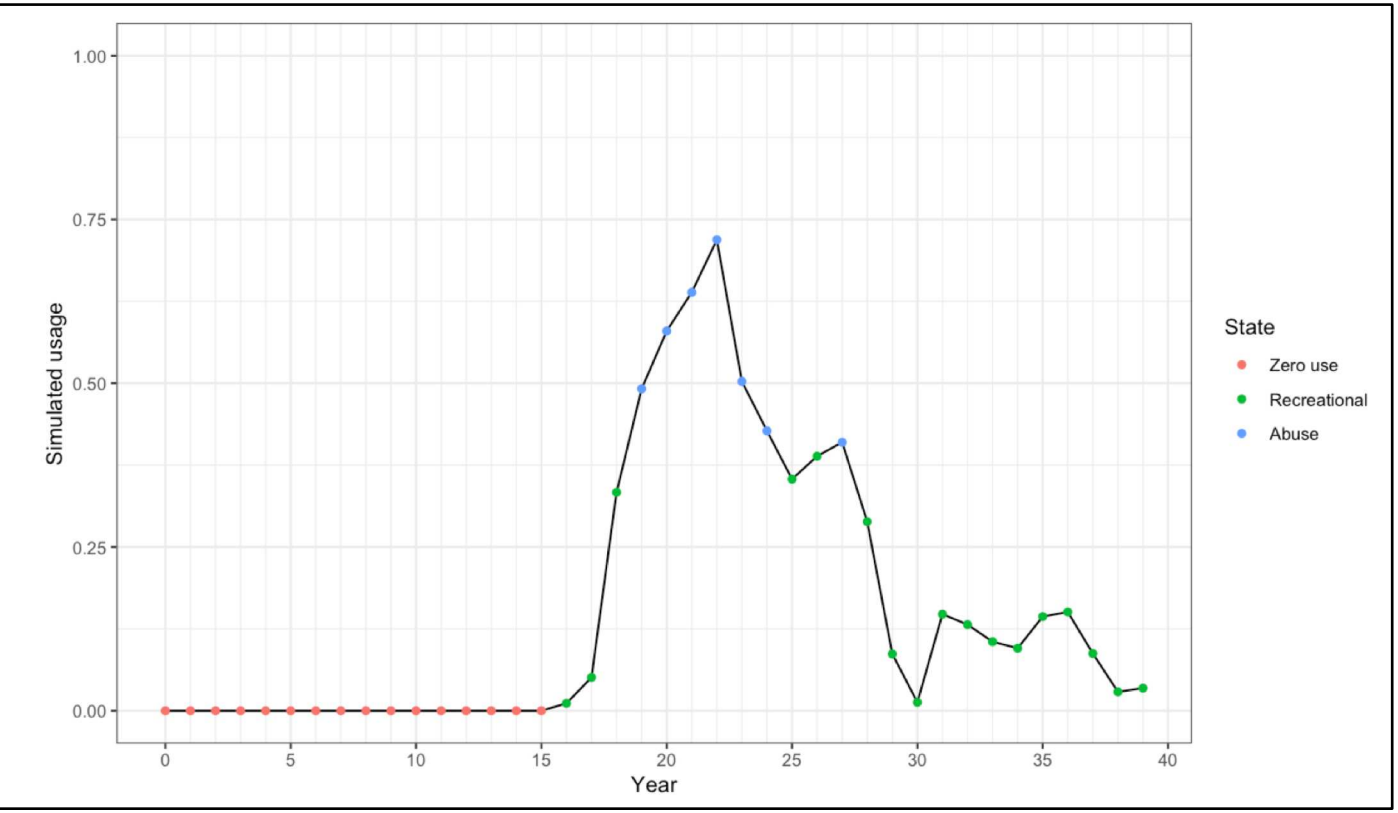
$$\frac{\partial S}{\partial t} = r_s \times S \times (1 - S) \times \left(1 - \frac{S}{S_{\text{eq}}}\right)$$

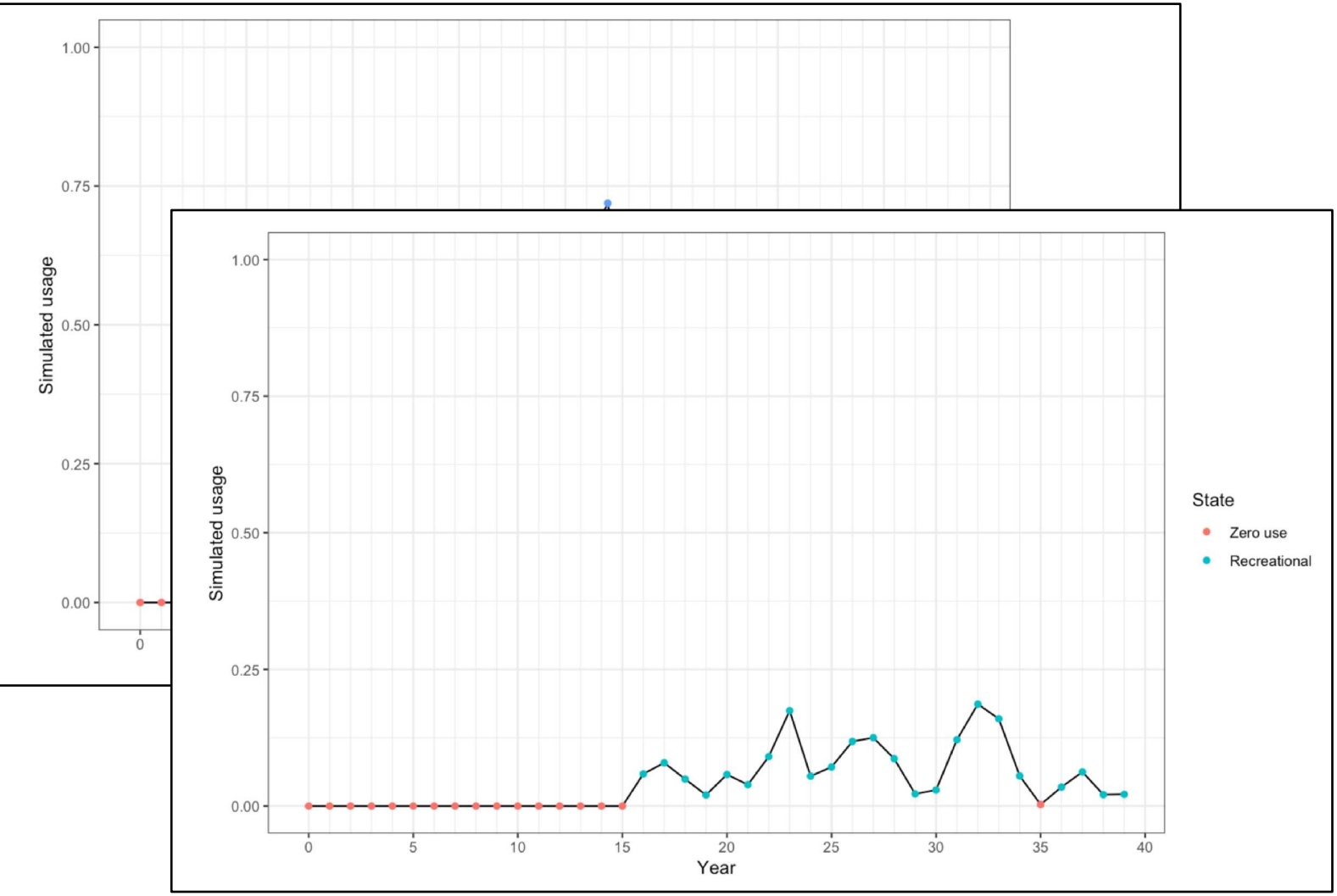
$$\frac{\partial N}{\partial t} = r_n \times (1 - N) \times \left(1 - \frac{N}{N_{\text{eq}}}\right)$$

After age 16:
small usage shock
every 4 months.

Parameter	Explanation	Value
U	Usage	Starts at 0
S	Self-control	Start at 1
N	Negative consequences	Start at N_{lower}
P	Positive consequences	See below
r_u	Rate of U dynamics	0.25
r_s	Rate of S dynamics	0.1
r_n	Rate of N dynamics	0.1
A	Addictiveness or Proneness	Drawn from $U(0.2, 0.4)$
N_{lower}	N lower bound	Drawn from $U(0.1, 0.3)$
p_n	Exponent	1
H	Point at which Self-control is 0.5	Drawn from $U(0.5, 0.9)$
p_s	Exponent	7




1.00
0.75
0.50
0.25
0.00
Simulated usage
0
5
10
15
20
25
30
35
40
Year
State
Zero use
Recreational
Abuse


1.00
0.75
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0.00
Simulated usage
0
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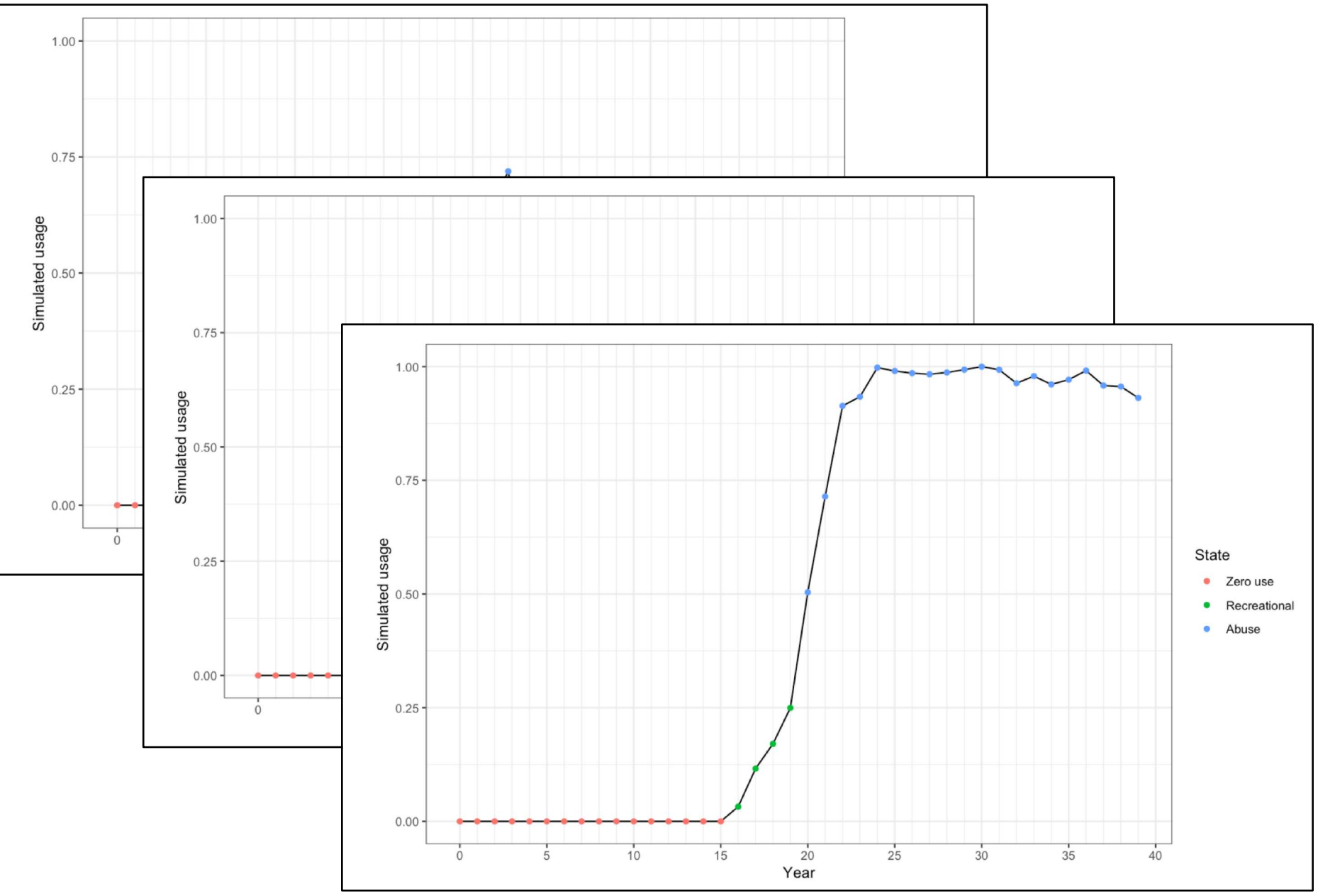
Year
State
Zero use
Recreational


Simulated usage
1.00
0.75
0.50
0.25
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5
10
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20
25
30
35
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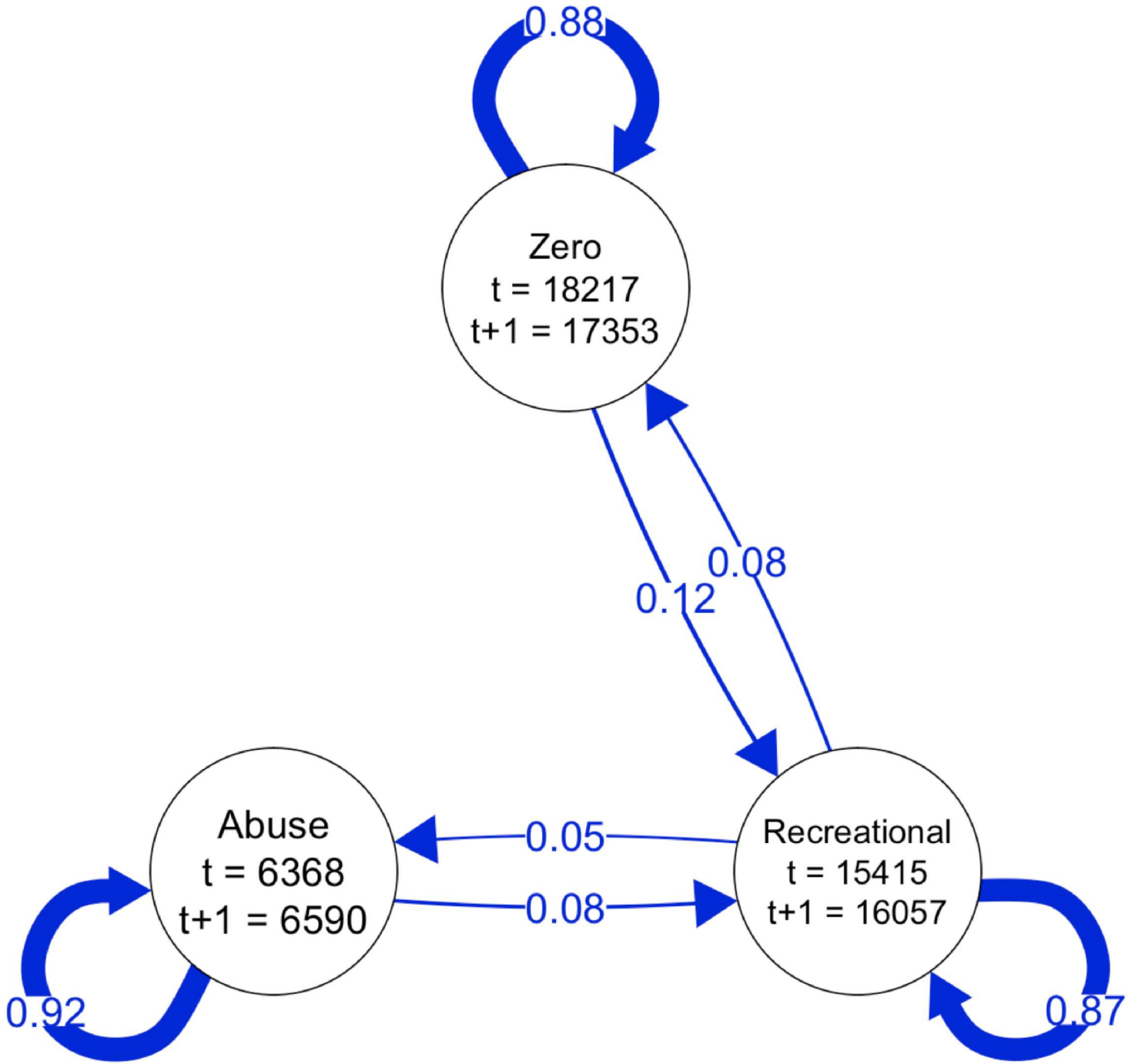
Year
State
Zero use
Recreational
Abuse


0.88
Zero
t = 18217
t+1 = 17353
0.12
0.08
Abuse
t = 6368
t+1 = 6590
0.05
0.08
Recreational
t = 15415
t+1 = 16057
0.92
0.87

Call for Speakers!

Satellite session on complexities of adverse behavior

Acknowledgements

Workshop Dynamical systems, networks, and psychopathology: Marieke Wichers, Jessica Hartmann, Laura Bringmann, Angélique Cramer, Claudia van Borkulo, Kenneth Kendler, Roseann Peterson, Hanna van Loo, Han van der Maas, lJolanda Kossakowski, Lourens Waldorp, Denny Borsboom, Sacha Epskamp, Eiko Fried, Marten Scheffer, Egbert van Nes, Sanne Gijzel, Don Robinaugh, and Gaby Lunansky.

Thank you for your attention!

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The Psych Systems Project