How many parameters to model states of mind?

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Purpose and **outline of this talk**

Self-presentation

Promotion of explanatory function of models (at cost of prediction)

- Why (we) model?
- Mind – latent variables
- Examples of models
- Less is better

Why simulation models? (B. Edmonds, 2003)

(…)

Pseudo-Mathematics, to determine the properties of the simulation in the abstract (see also BE, 2010: an attempt to simply understand the middle, inference step of the modelling process)

(…)

<u>Science</u>, i.e. helping to understand observed phenomena

- **Predictive (if they fit to new data)**
- **Explanatory (if they explain old data)**
- Analogical (=>Yet Another Way Of Thinking About Stuff)

If YAWOTAS fits, wear it.

Behavioral *vs* hermeneutic

There have been two very different approaches to social explanation since the nineteenth century, and they differ most fundamentally over a distinction between „explanation” and „understanding” or „**cause**” and „**meaning**” (…). This distinction divides over two ways of understanding a „why” question when it comes to social events. „Why did it happen?” may mean „What caused it to happen?”; or it may mean „Why did the agents act in such a way to bring it about?”. The *hermeneutic* approach holds that the most basic fact of social life is the meaning of an action.

[Daniel Little, 2008]

If men define situations as real, they are real in their consequences.

[W.I. Thomas and D. S. Thomas, 1928]

Scientific theory is:

- general (not limited to a single case)
- expressed in neutral, objective and unambiguous language
- testifiable with reproducible methods and empirical facts

Can sociological theories be scientific?

[Jonathan H. Turner, 1998]

Latent variables - types of definitions

a) informal

- hypothetical (exist in the minds and magazines of psychologists)
- **impossible to measure** *(so what?)*
- data reduction device (function descriptive)

b) local independence

$$P[Y_1, Y_2, \ldots, Y_K] = P[Y_1|\eta]P[Y_2|\eta]\ldots P[Y_K|\eta]$$

c) true score

$$T_i = E(Y_i) = E(T_i + \varepsilon_i)$$

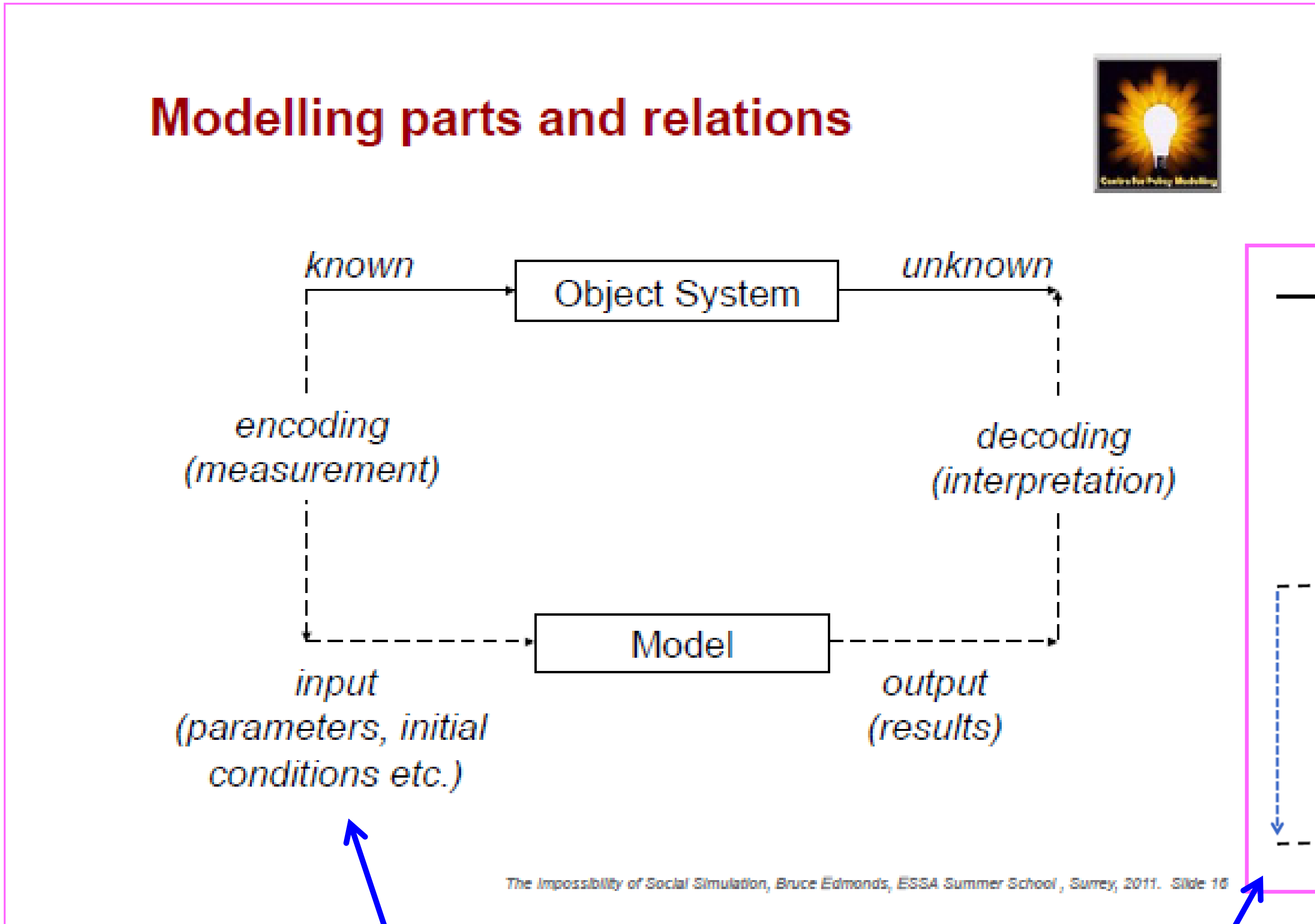
d) nondeterministic : **cannot be obtained from observed variables**

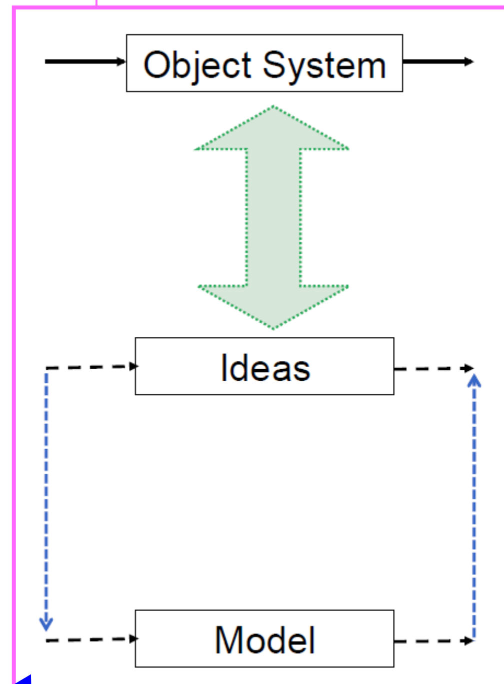
e) not measured in a given experiment

[K. A. Bollen, Annu. Rev. Psychol. 53 (2002) 605]

The Impossibility of Social Simulations, Bruce Edmonds, Surrey, 2011, Slides 16 and 19

(www.simian.ac.uk/SimianResources/ESSA-SS2011/Presentations/Impossibility%20of%20Social%20Simulation%20-%20ESSA%20Sum%20Sch%202011.pdf)





how many latent parameters?

Example 1: The Zaller model of mass opinion –
- *data model of a collective mind*

The model parameters:

- political awareness W_i

- predisposition p_i of i to accept the message, and it depends on the ideological relation of i to the message content

- The probability of receipt a message relevant for the opinion formation

$$f(W_i; a_0, a_1) = 1 - [1 + f + \exp(a_0 + a_1 W_i)]^{-1}$$

- Provided that a message is received by i, the probability of its acceptance

$$g(W_i, p_i; b_0, b_1, b_2) = [1 + \exp(-b_0 - b_1 W_i - b_2 p_i)]^{-1}$$

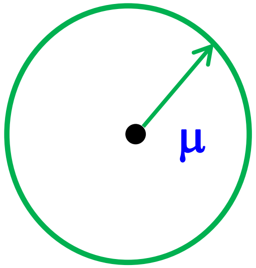
- The probability to recall a previously accepted opinion

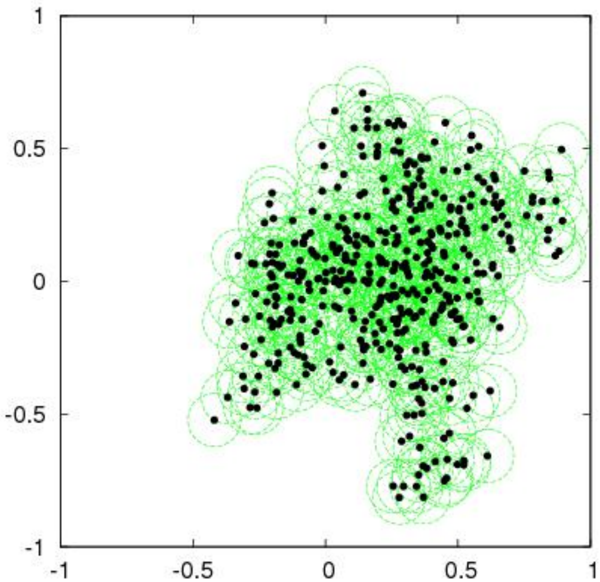
$$h(W_i, p_i; b_0, b_1, b_2) = [1 + \exp(c_0 + c_1 W_i)]^{-1}$$

[J. R. Zaller, The Nature and Origin of Mass Opinion, Cambridge UP 1992]

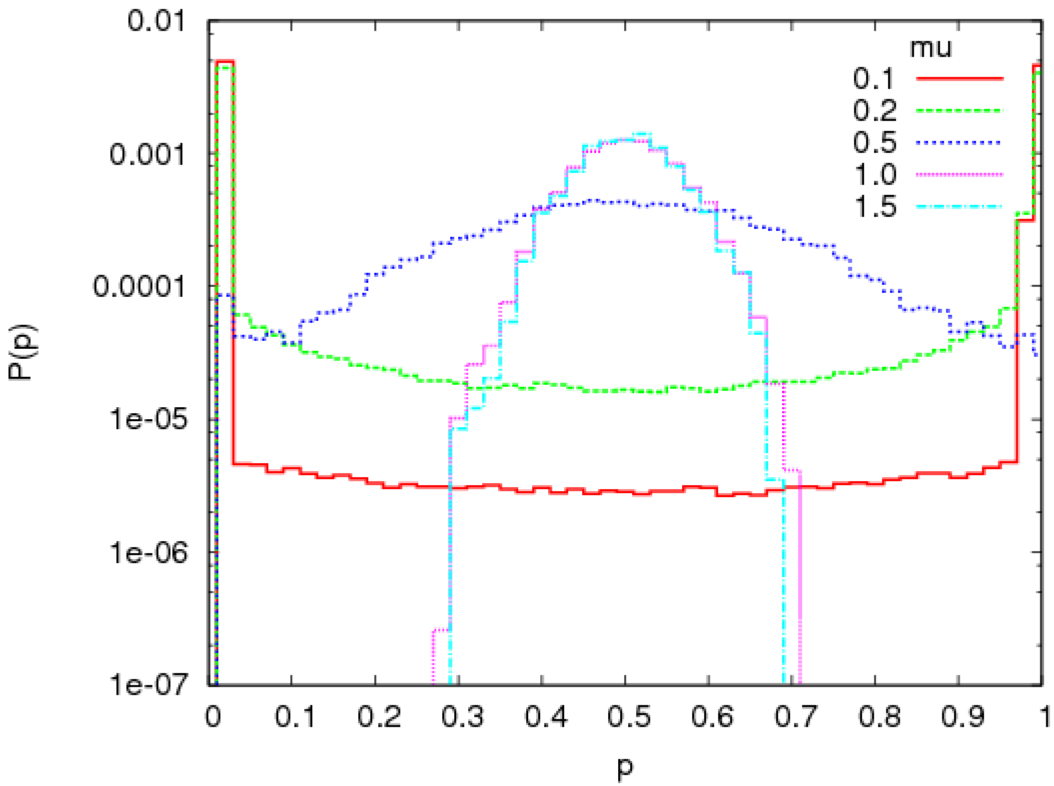
Example 2: Zaller-Deffuant model of bounded confidence - *pseudomathematical or YAWOTAS?*

one threshold parameter μ



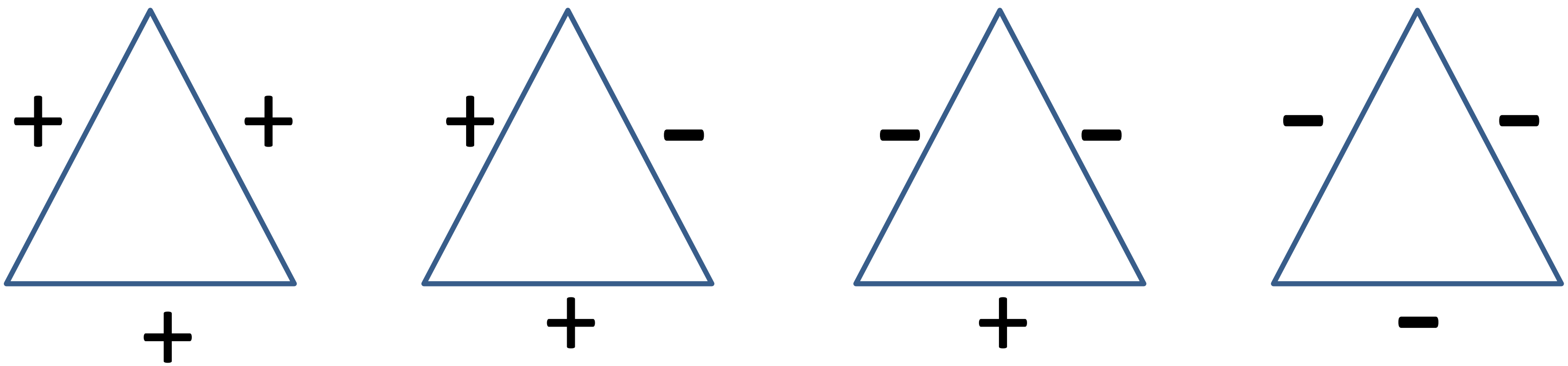


Typical result:
small capacity μ =>
=> opinion polarization



[K. Malarz et al., JASSS 14 (2011) issue 1]

Example 3: Removal of cognitive dissonance - *explanatory*

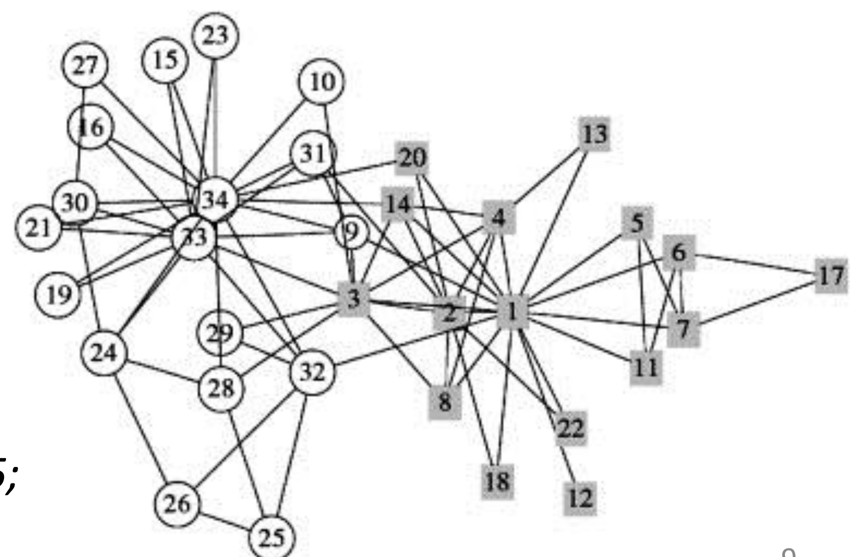


Friend of my friend is my friend
Friend of my enemy is my enemy
Enemy of my friend is my enemy
Enemy of my enemy is my friend

$$\frac{dw_{ij}}{dt} = (1 - w_{ij}{}^{2}) \sum_{k} w_{ik} w_{kj}$$

[P. Gawroński, K.K., AIP Conf. Proc. 779, NY, 2005; S. A. Marvel et al., PNAS 108 (2011) 1771]

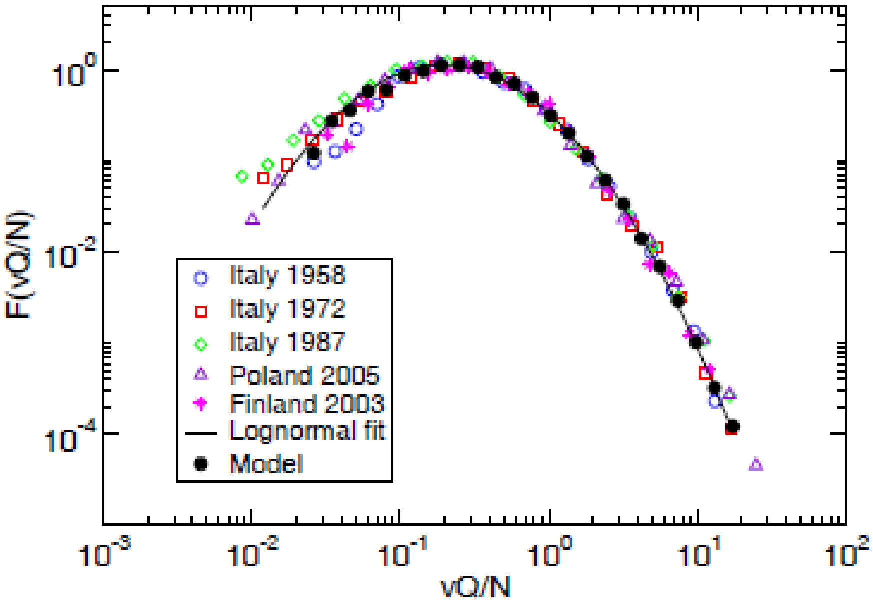
Zachary data, 1977: exact accordance



Example 4: Lognormal distribution of votes - *predictive*

$$P(v,Q,N) = \frac{N}{\sqrt{2\pi}\sigma v Q} \exp \frac{-[\log(vQ/N)-\mu]^2}{2\sigma^2}$$

v – number of votes for a candidate
Q – number of candidates of a given party
N – number of votes for this party
μ= -0.54
σ^2= -2μ = 1.08



Confirmed later for Estonia (the data after 2002) and for Denmark, but not for Brazil, Greece, Czech, Netherlands, Belgium, Sweden, Urugway.

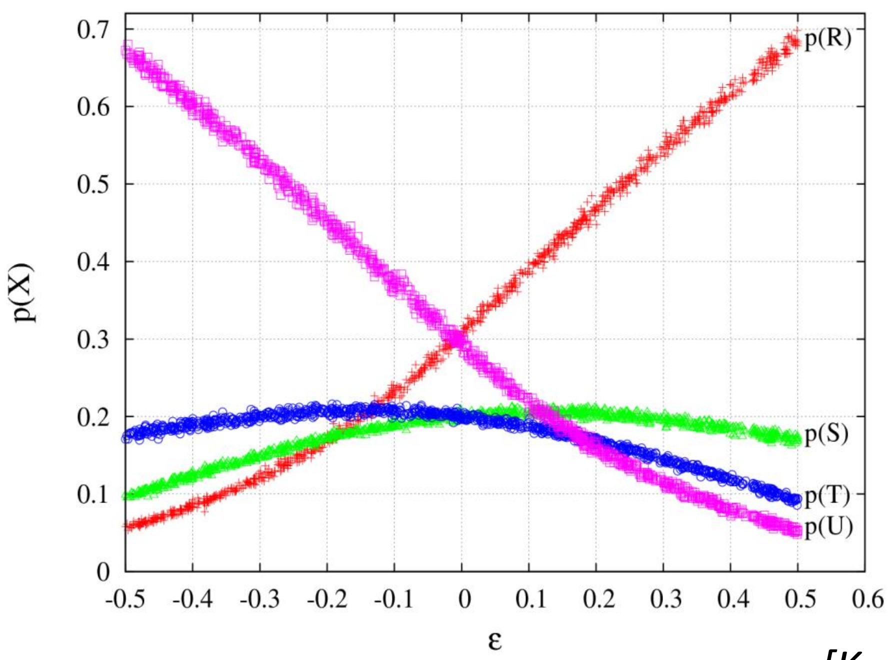
[S. Fortunato, C. Castellano, PRL 99 (2007) 138701;
A. Chatterjee et al., Sci. Rep. 3 (2013) 1049]

Example 5: a minimal model of cooperation - *YAWOTAS*

Individual parameters: altruism $\varepsilon(i) \in (-1/2, 1/2)$, reputation $W(i) \in (0,1)$

$$W(i) \to \begin{cases} 1/2 + W(i)/2 & \text{if } i \text{ cooperates} \\ W(i)/2 & \text{if not} \end{cases}$$

The probability that *i* cooperates with *j* is $P(i, j) = F[\varepsilon(i) + W(j)]$



where F[x] – a simple increasing function

Main result:
cooperation survives,
but those with $\varepsilon < 0$
are excluded

[K. K., P. Gawronski, Physica A 388 (2009) 3581]

Example 6: a model of emotion sharing

Table 1. Optimal parameter settings found

Global parameters (not tuned)		Initial variable settings (not tuned)		Global parameters (tuned)		Initial variables (tuned)	
#agents	35	$\varepsilon_{intention}$	0.5	$\tau_{distance}$	190	$q_{belief(nomove)}$	0.005
max_x	600	$\delta_{intention}$	0.5	sight_reach	200		
max_y	800	$\eta_{intention}$	0.5	max_speed (per agent)	see Fig.3		
Δt	0.5	$\beta_{intention}$	0.5				
$\mu_{\delta belief}$	0.5	ε_{belief}	0.5				
$\mu_{\eta belief}$	0.5	δ_{belief}	0.5				
$\mu_{\beta belief}$	0.5	η_{belief}	0.5				
ζ_{belief}	0.5	β_{belief}	0.5				
σ	100	$\varepsilon_{emotion}$	0.5				
ω_{OIA1}	0.3	$\delta_{emotion}$	0.5				
ω_{OEA2}	0.3	$\eta_{emotion}$	0.5				
ω_{OBA2}	0.3	$\beta_{emotion}$	0.5				
ω_{OEA1}	0.5						
ω_{OBA1}	0.5						
all $q_{belief(X)}$	0						
impact of event on $q_{belief(X)}$	1						
min_speed	0.01						

fear of agent *A*	$q_{fearA}(t)$
emotion for option *O* of agent *A*	$q_{emotion(O)A}(t)$
intention indication for option *O* of agent *A*	$q_{intention(O)A}(t)$
belief in *X* of agent *A*	$q_{belief(X)A}(t)$

$\mu_{\delta beliefA}, \mu_{\eta beliefA}, \mu_{\beta beliefA}$	adaptation speed for δ, η, β for beliefs
$\sigma_A,\ \tau_A$	steepness and threshold values for adaptation
ζ_A	optimistic/pessimistic bias upon fear
ν_A	weight of fear against beliefs
$\omega_{X,fear,A}$	weight of information *X* for fear
ω_{OEA1}	weight of the group impact on the emotion of *A* for *O*
ω_{OBA1}	weight for the own belief impact on the emotion of *A* for *O*
ω_{OIA1}	weight for the group impact on the intention of *A* for *O*
ω_{OEA2}	weight for own emotion impact on the intention of *A* for *O*
ω_{OBA2}	weight for the own belief impact on the intention of *A* for *O*

[T. Bosse et al., LNAI 6704 (2011) 566]

Example 6: a maximal model of emotion sharing - ?

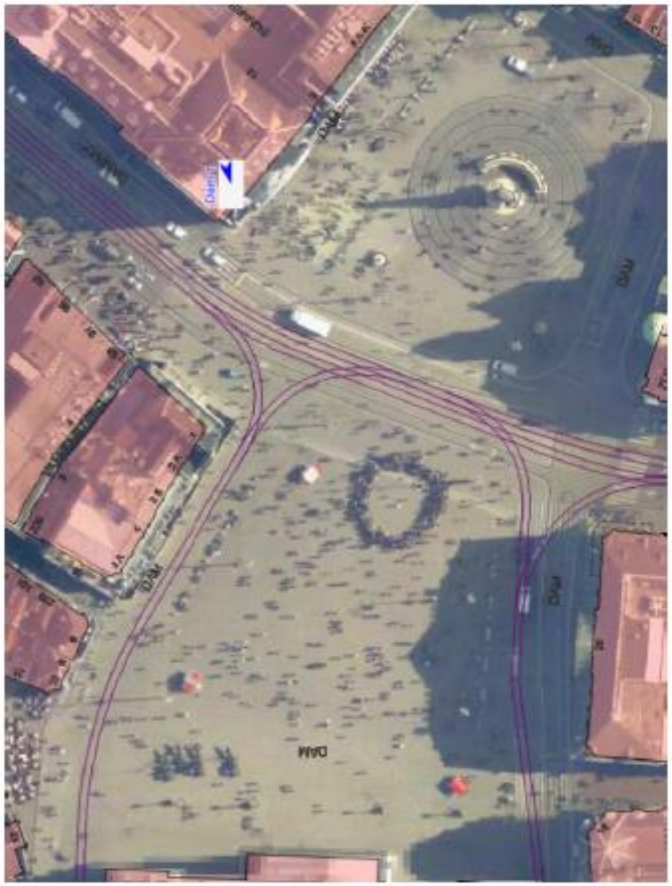


Fig. 2. 600 x 800 pixel image of the Dam Square

$$\varepsilon = \sum_{agents\ a} \sum_{timepoints\ t} \frac{\sqrt{(x(a,t,sim)-x(a,t,data))^2+(y(a,t,sim)-y(a,t,data))^2}}{\#agents\ \#timepoints}$$

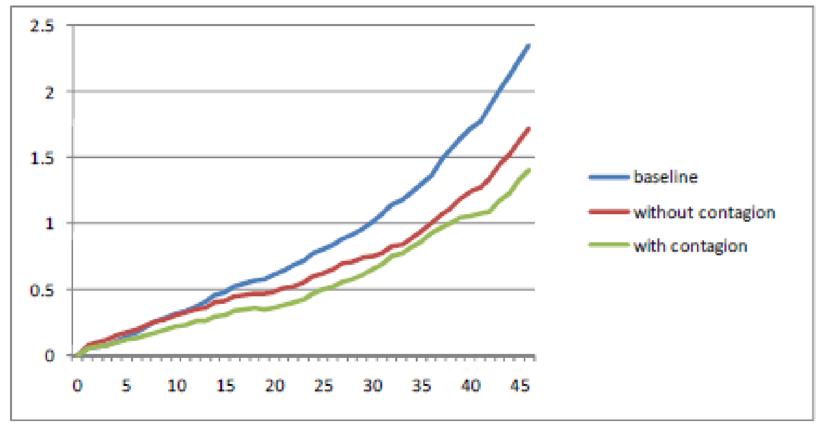


Fig. 3. Development of error over the simulation for three variants of the model.

Main result: the variant with contagion of emotions gives the lowest error

[T. Bosse et al., LNAI 6704 (2011) 566]

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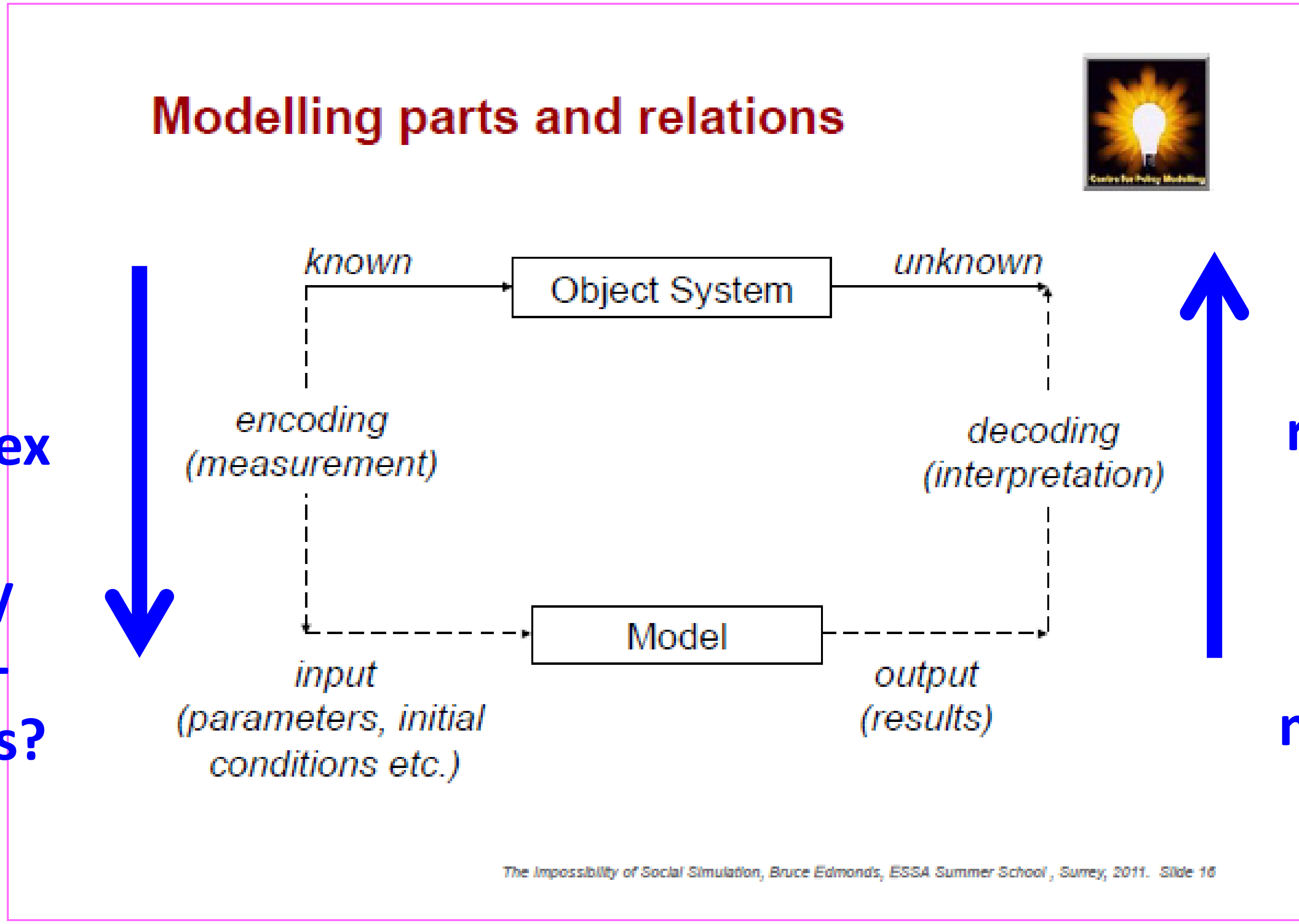
Too complex with many para-meters?



Less reliable with many para-meters?

Summary: less is better

Either we can evaluate our parameters, or the sensitivity analysis is necessary.

In the case of latent parameters, the latter analysis seems unavoidable.

But when the number of parameters is large, this analysis is very costly.

Perhaps a predictive model is possible only if the values of the latent variables do not influence the main result.

TAKK