The relation between mental and computer models:

some experiment in the management of natural resources

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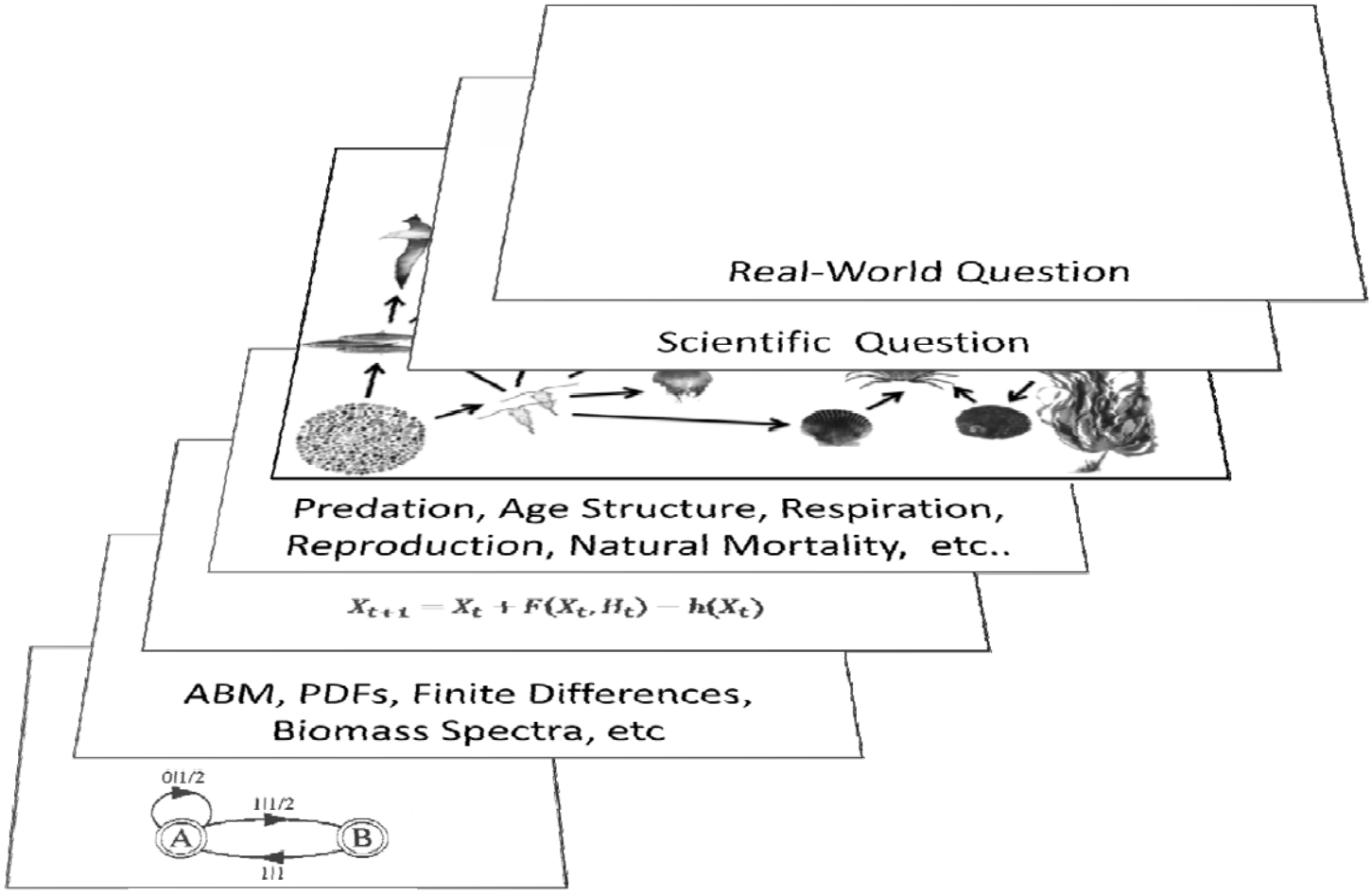
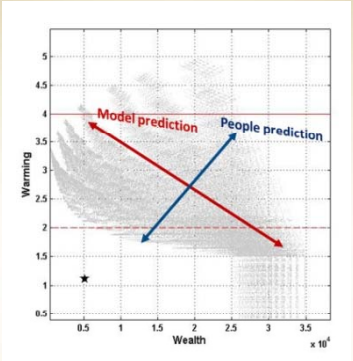
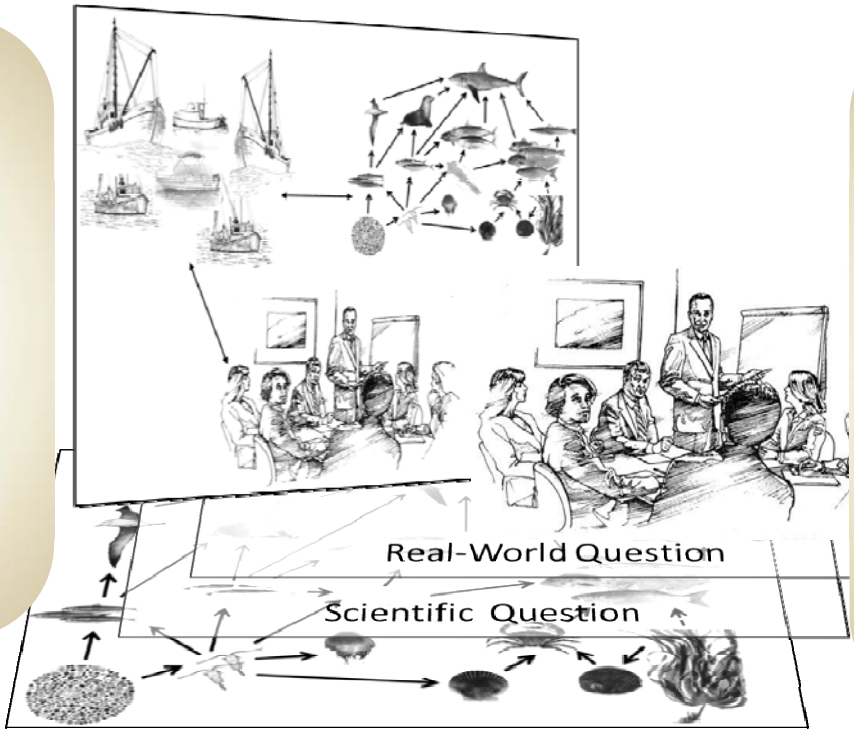
CSIRO Marine and Atmospheric Research, Australia


Real-World Question
Scientific Question
Predation, Age Structure, Respiration,
Reproduction, Natural Mortality, etc..
$X_{t+1} = X_t + F(X_t, H_t) - h(X_t)$
ABM, PDFs, Finite Differences,
Biomass Spectra, etc
0|1/2
1|1/2
A
B
1|1

2

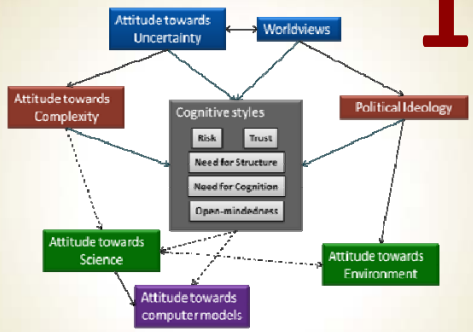


Numerical modeling of mental models



Model Understanding, Acceptance, Trust

1



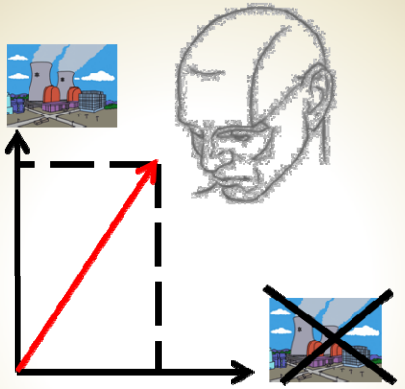
Complexity & Cognitive styles

Relation between mental and numerical models

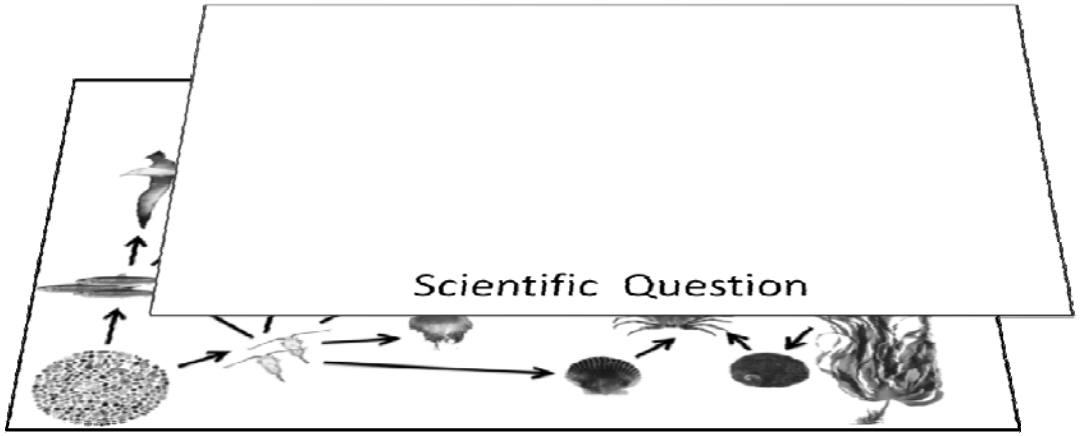
3

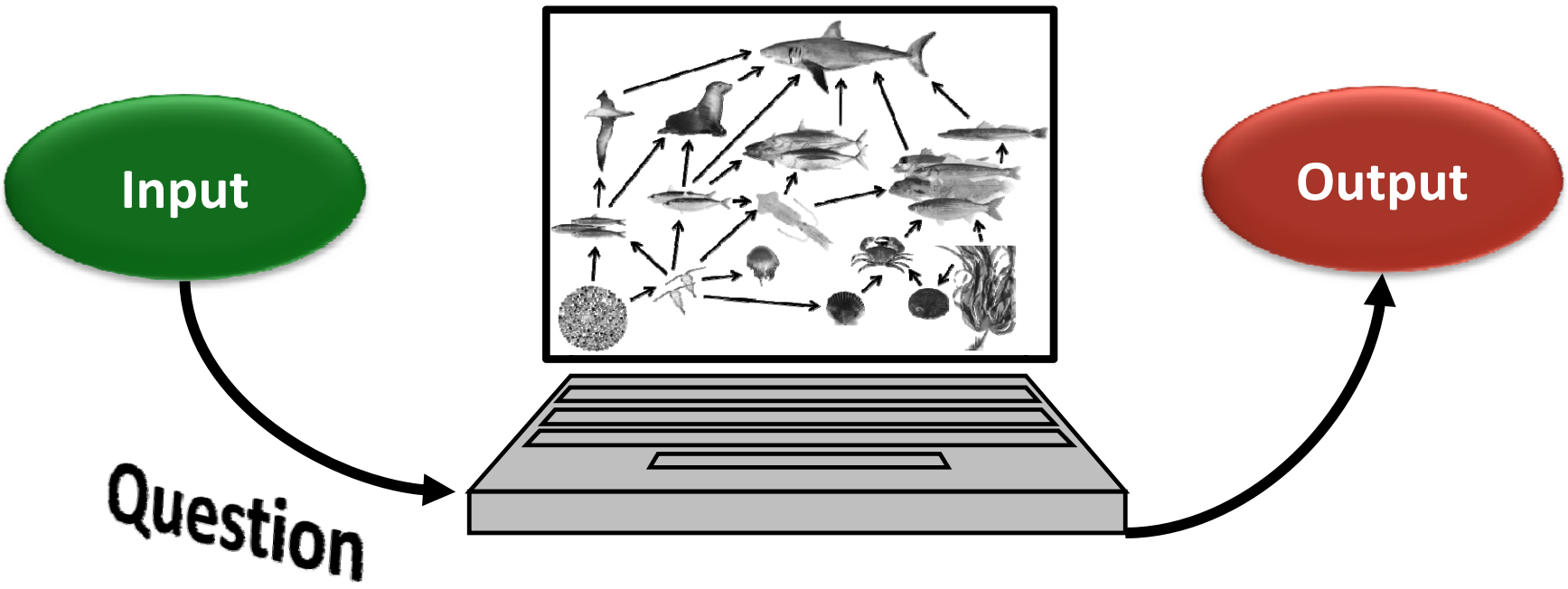
Emergence & Causation

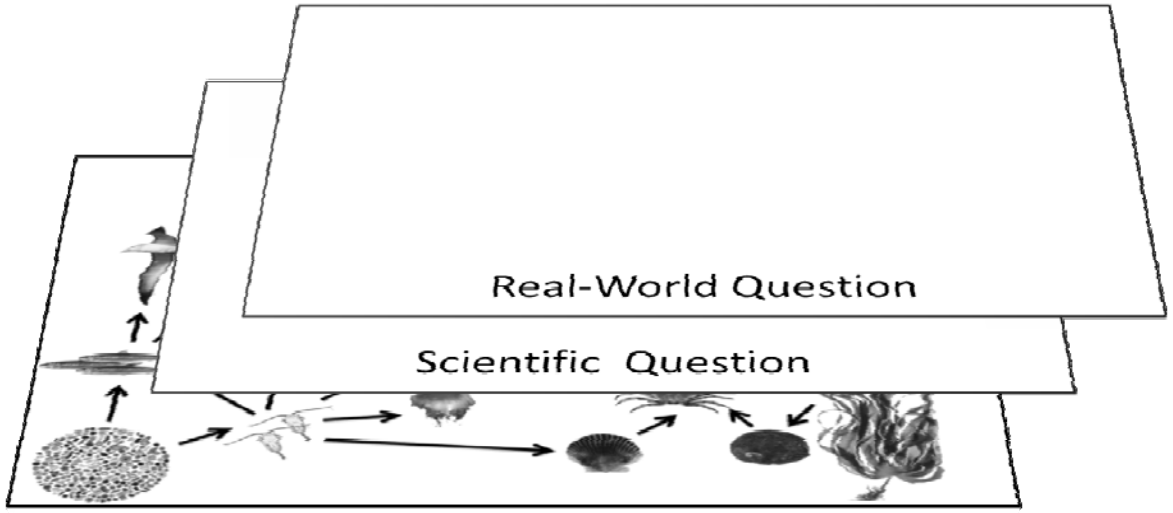
4



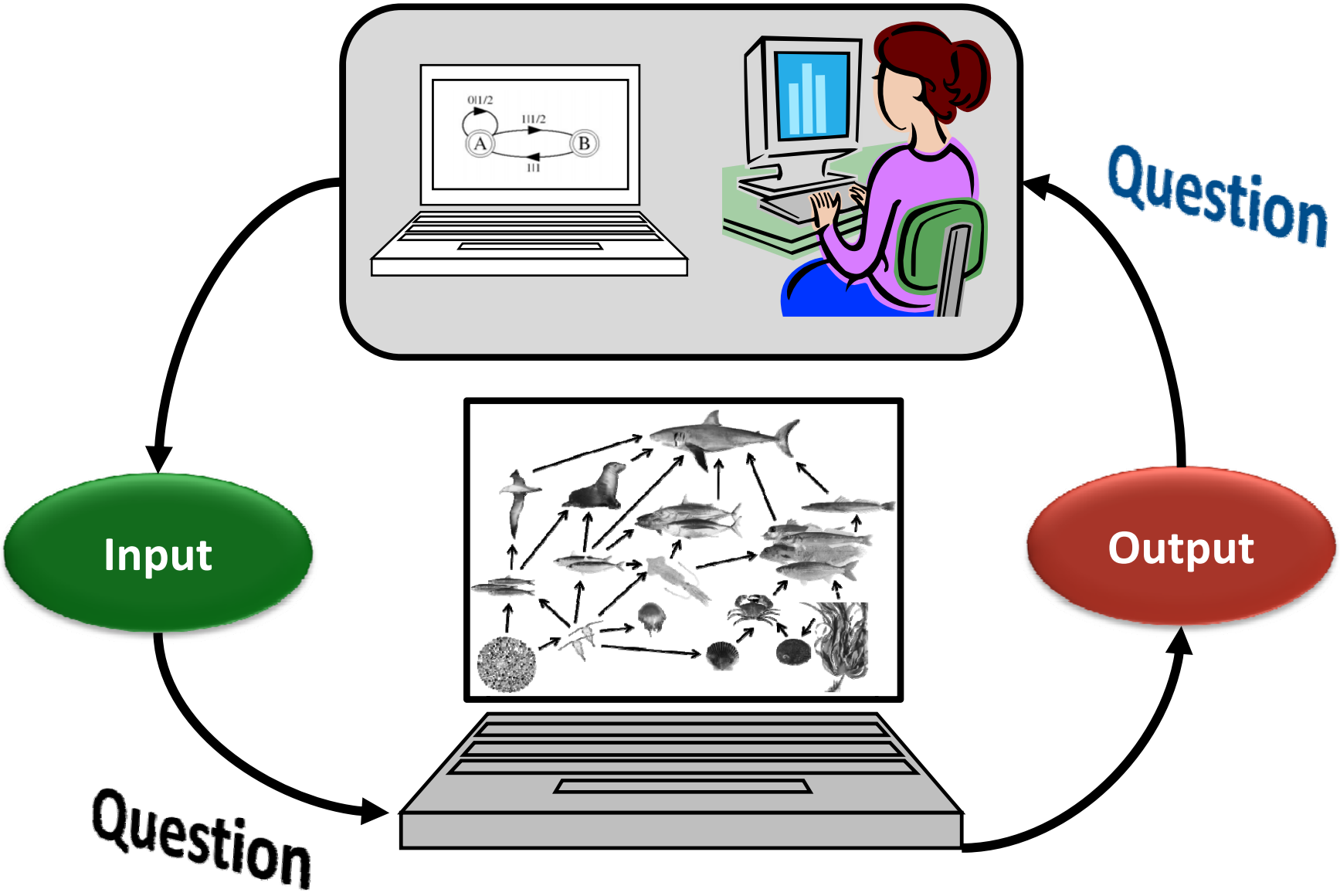
Attitudes, ideologies and self-organisation


Scientific Question


Input
Question
Output



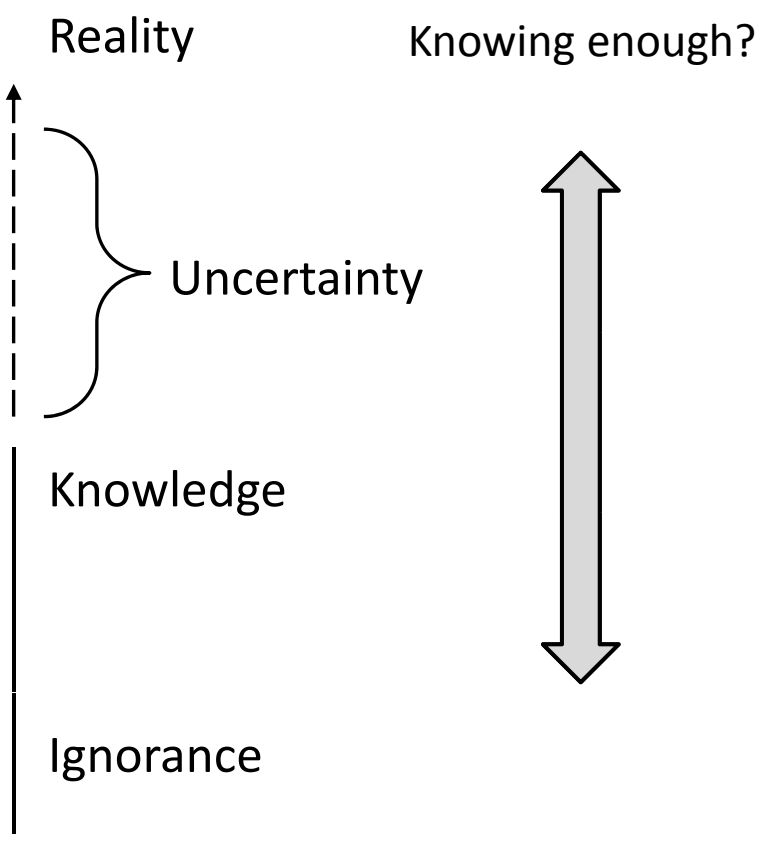
- Questions → Inverse Questions
- Uncertainty: Knowing too little → Knowing too differently
- Logical mistakes may lead to ‘wrong’ decision


0|1/2
1|1/2
A
B
1|1
Question
Input
Output
Question

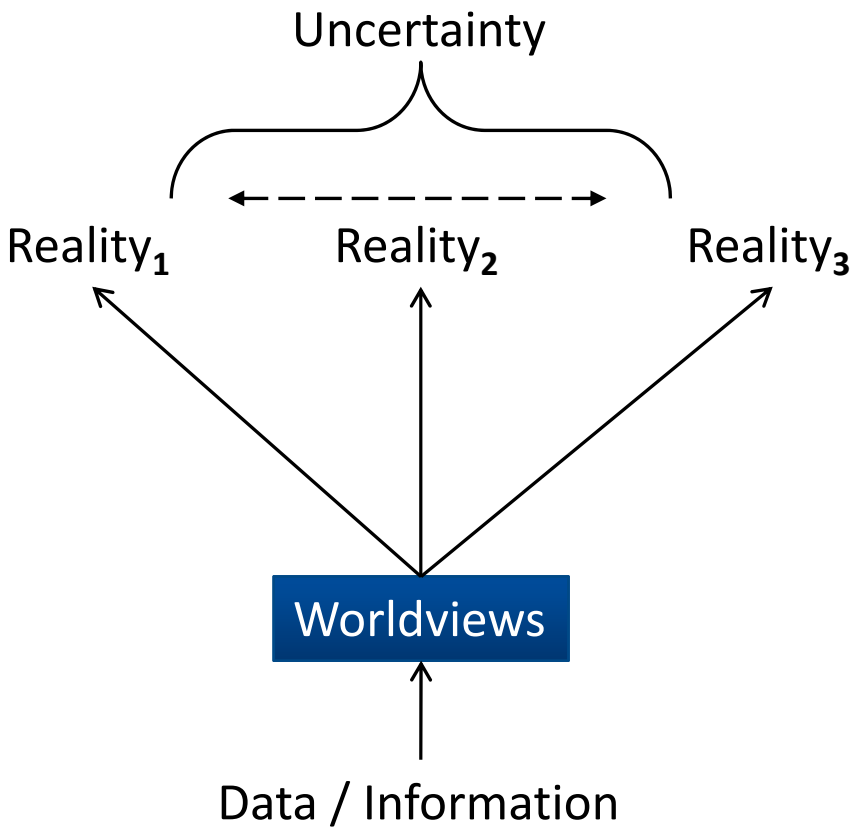
- **Data accuracy**
- **Model reliability**
- **Problem uncertainty...**

- **Context**
- **Type of problem**
- **Implications of the model**
- **Charisma and reputation**

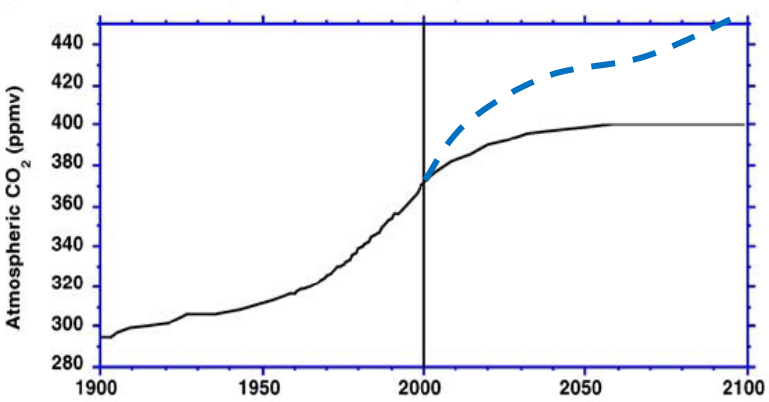
Physical Sciences **Decision**

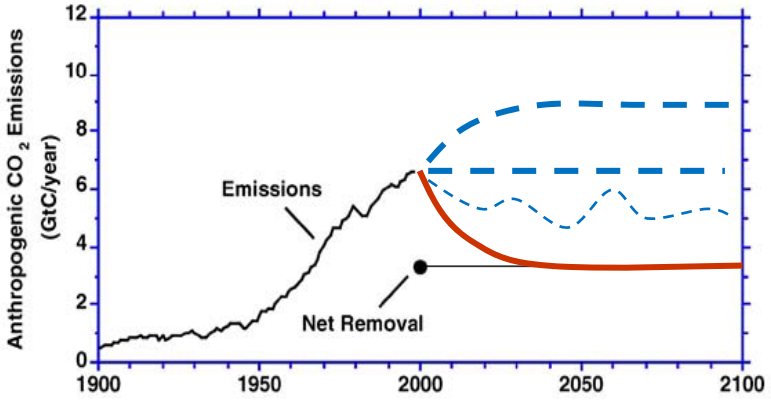


Cognitive-Social Sciences



Sterman, 2008, Science, 322, 5901, pp 532-533





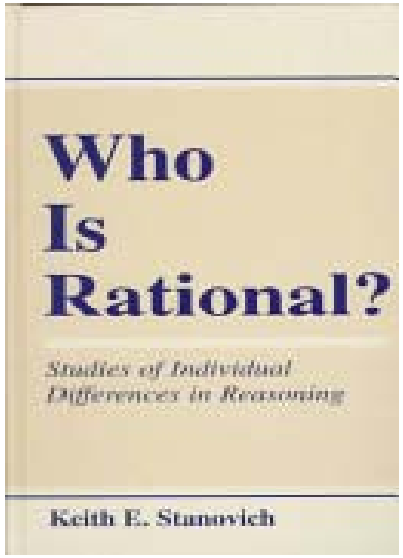
- No uncertainty
- Linear problem
- No need of specific knowledge
- No need of maths

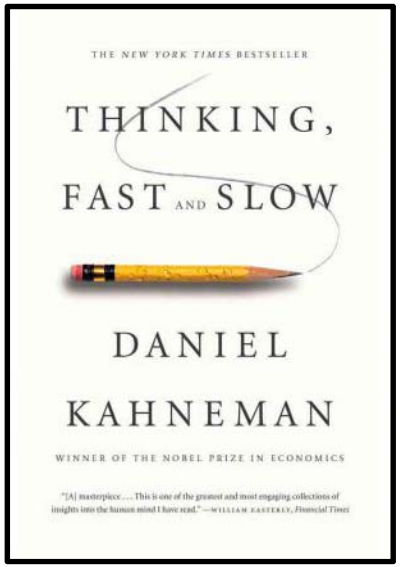
Group	**Wrong Answer**
Literature	~75%
CSIRO colleagues 1	66%
CSIRO colleagues 2	83%
Complex System workshop attendees	40%
Stakeholders Workshop (Ningaloo)	80%
Stakeholders Workshop (Southeast Fisheries)	>80%
Australian public (250)	70%

Different level of understanding of dynamical processes

Different level of trust in science/models

Different realities





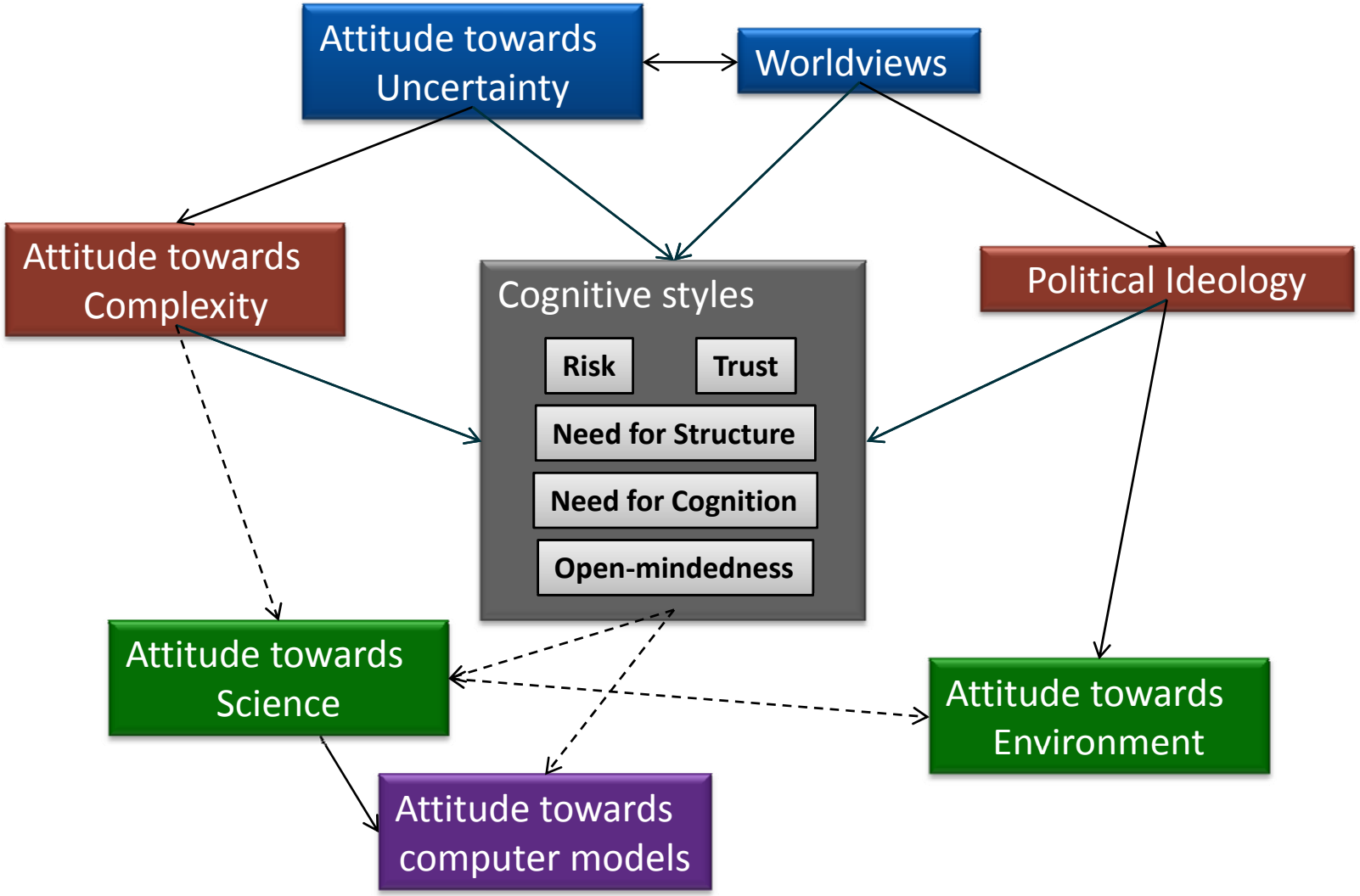
Technical / Behavioural' challenges

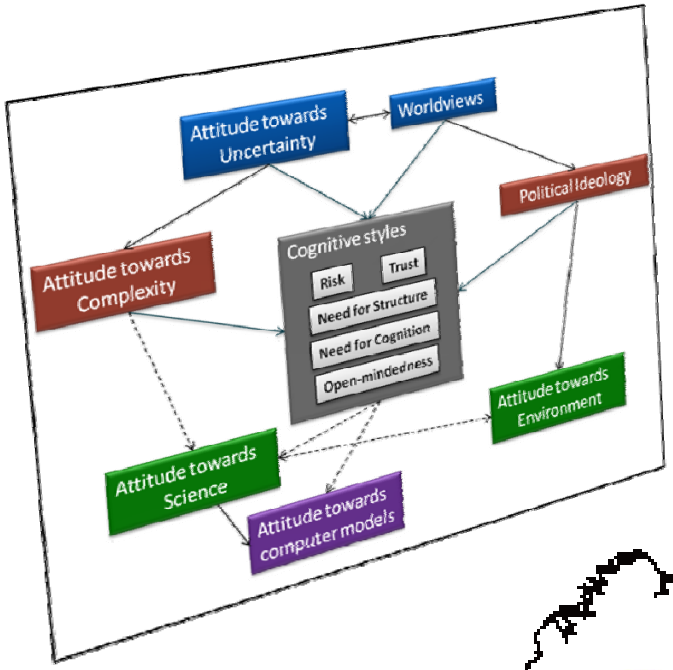
'Technical / Dynamics'

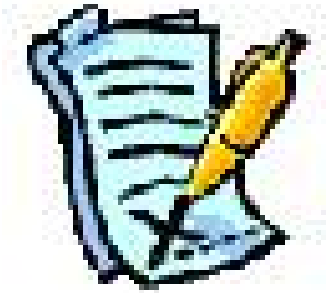
- Stock, flows & accumulation
- Exponential growth
- Time delays
- Long timescales
- Interdependencies
- Nonlinear processes
- etc…

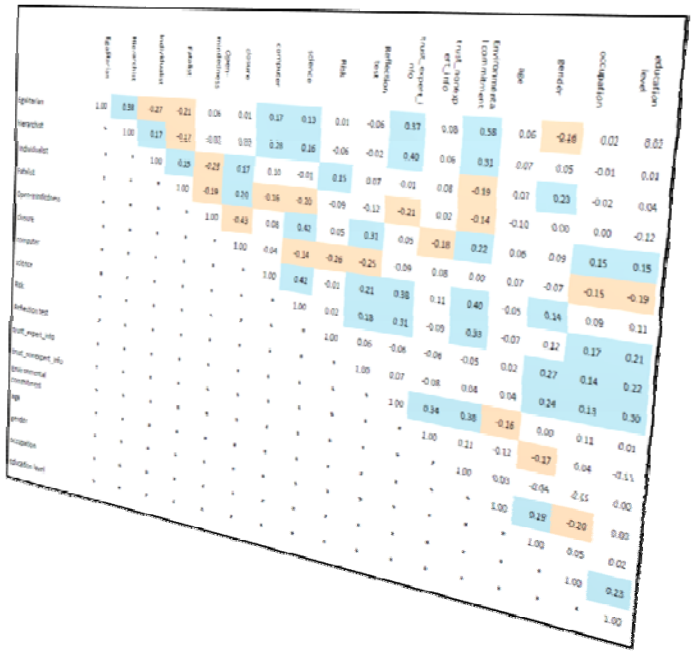
'Behavioural'

- Level of mental effort
- Effort time
- Questioning assumptions
- Stick to habits
- Contradictory goals
- Lack of self-reflection
- Impatience, frustration
- etc..


Attitude towards Uncertainty
Worldviews
Attitude towards Complexity
Cognitive styles
Risk
Trust
Need for Structure
Need for Cognition
Open-mindedness
Political Ideology
Attitude towards Science
Attitude towards Environment
Attitude towards computer models

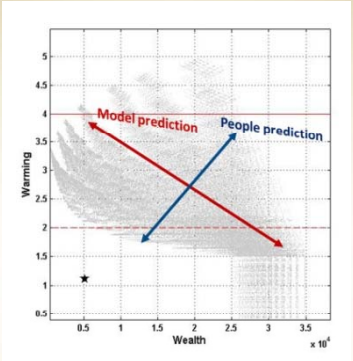




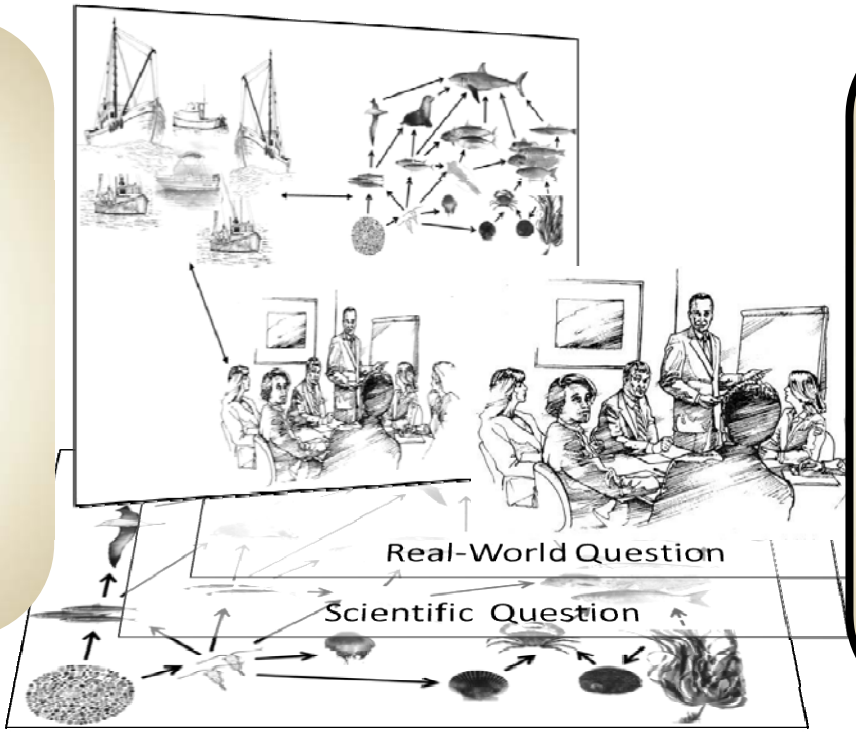


- To know our stake-holders
- Learn to communicate
- Learn to ‘model’ them

2

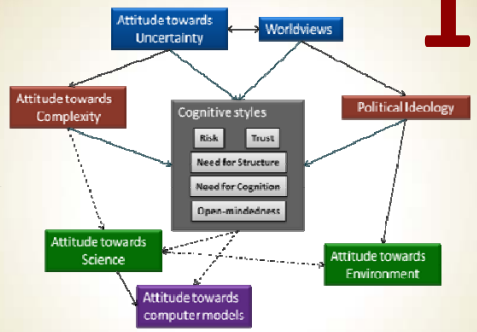


Numerical modeling of mental models

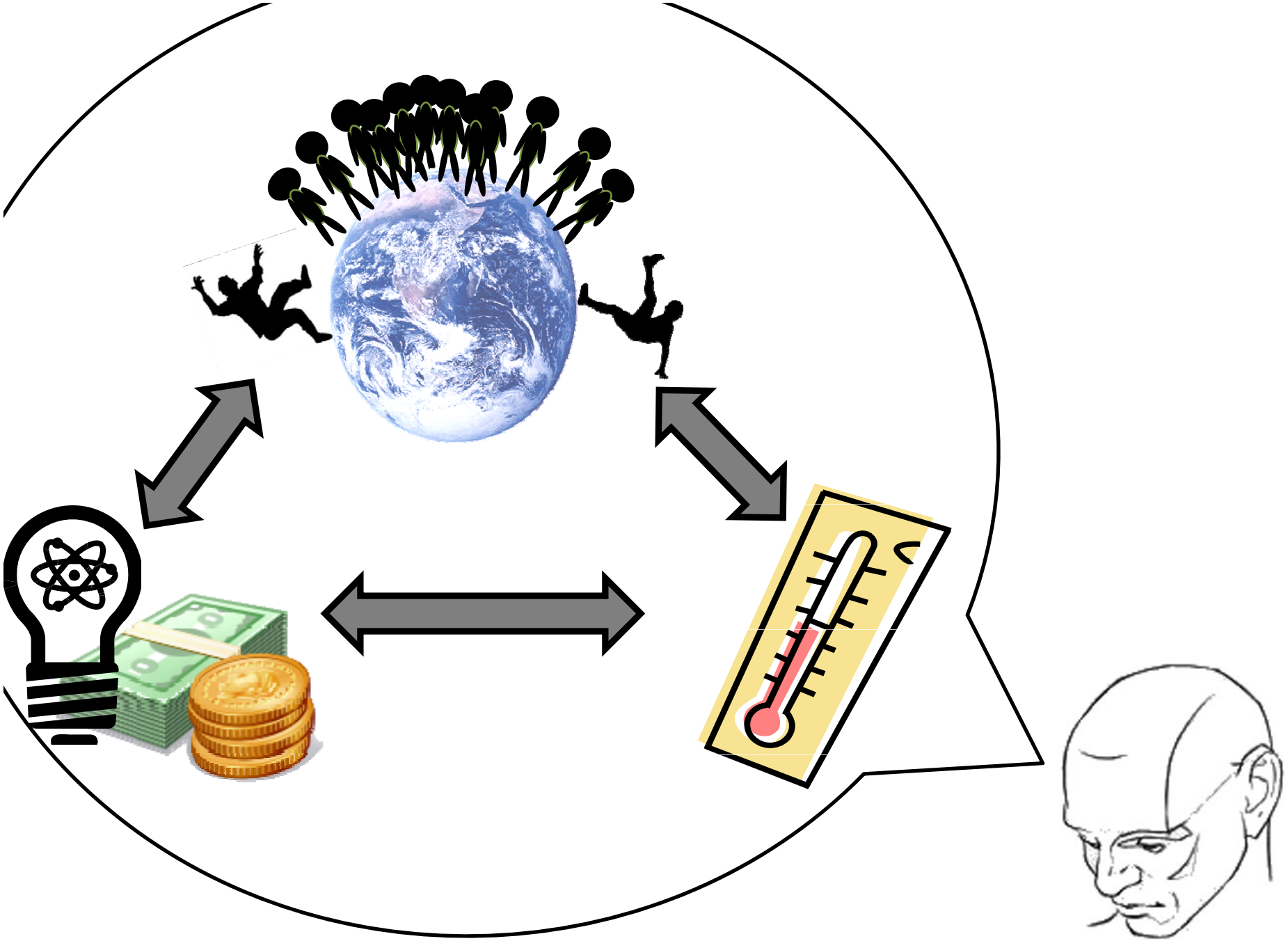


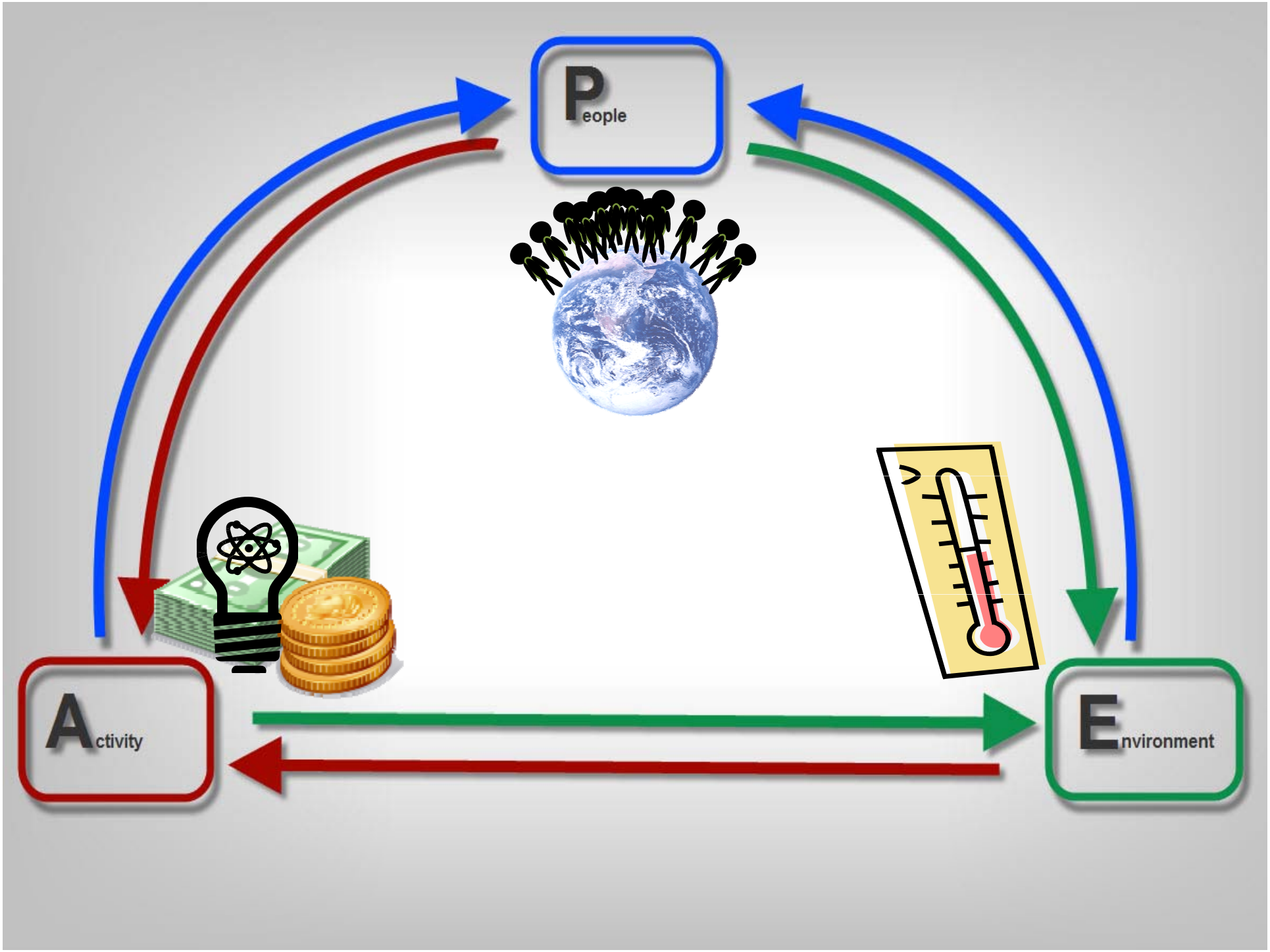
Model Understanding, Acceptance, Trust

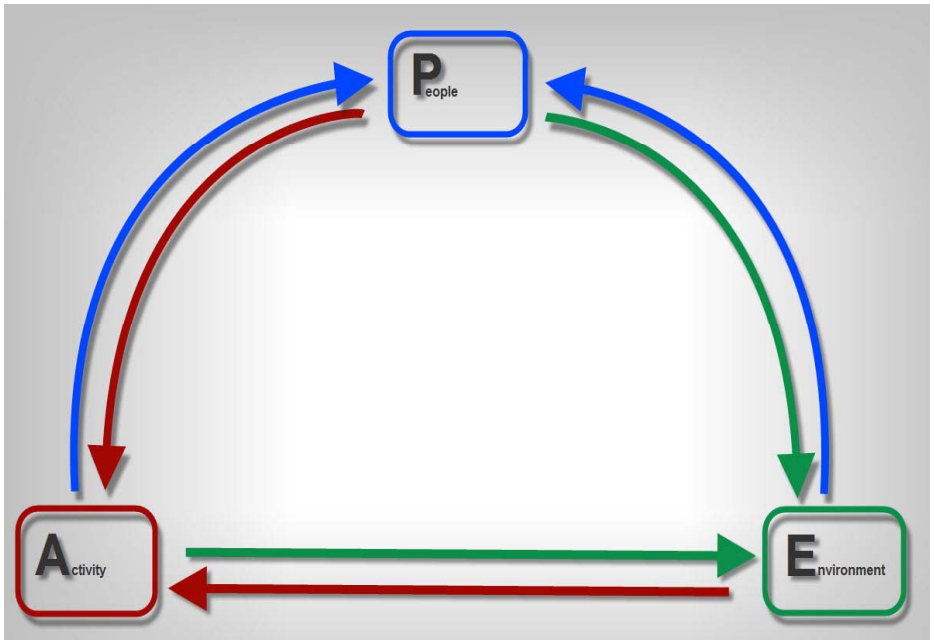
1



Complexity & Cognitive styles




People
Activity
Environment



Parameters:

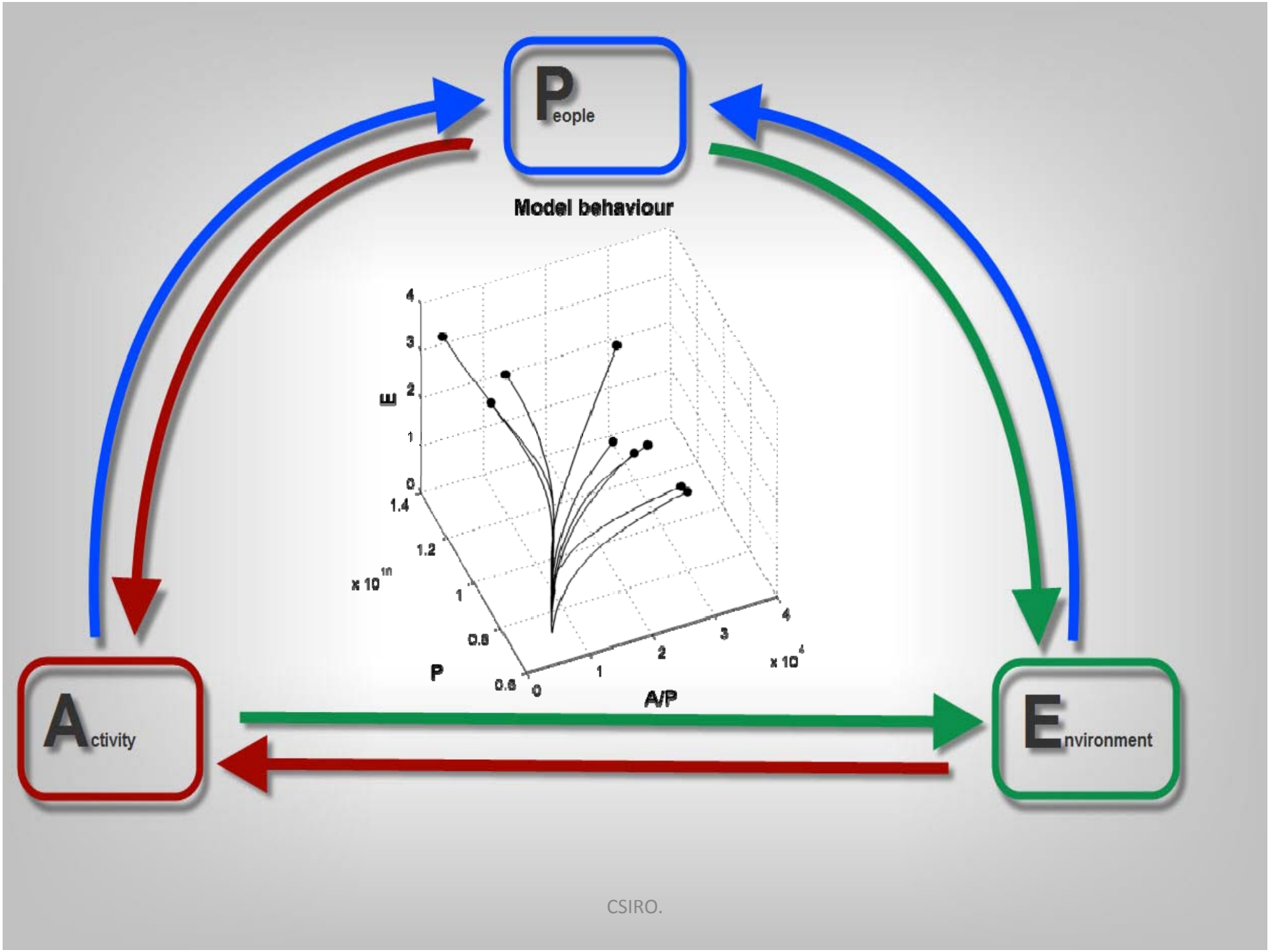
Physical
Economic
Demographic
Beliefs
Values

Beliefs

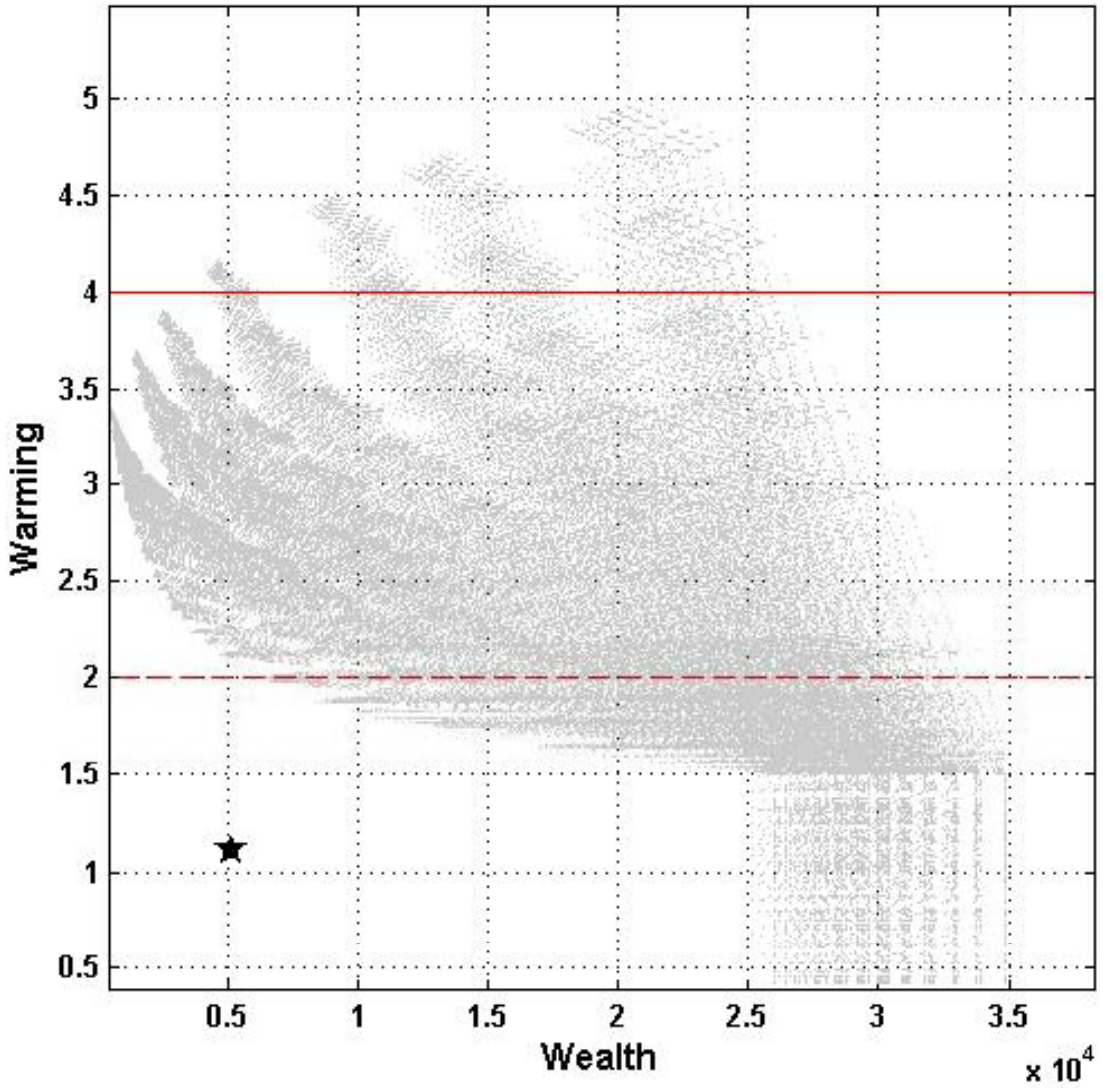
- **Climate sensitivity**: the rise on global temperature per CO2 doubling
- **Critical temperature**: "critical temperature value" past which human activity and GDP will be affected
- **Earth carrying capacity:** maximum number of people who could live on the Earth?

Values

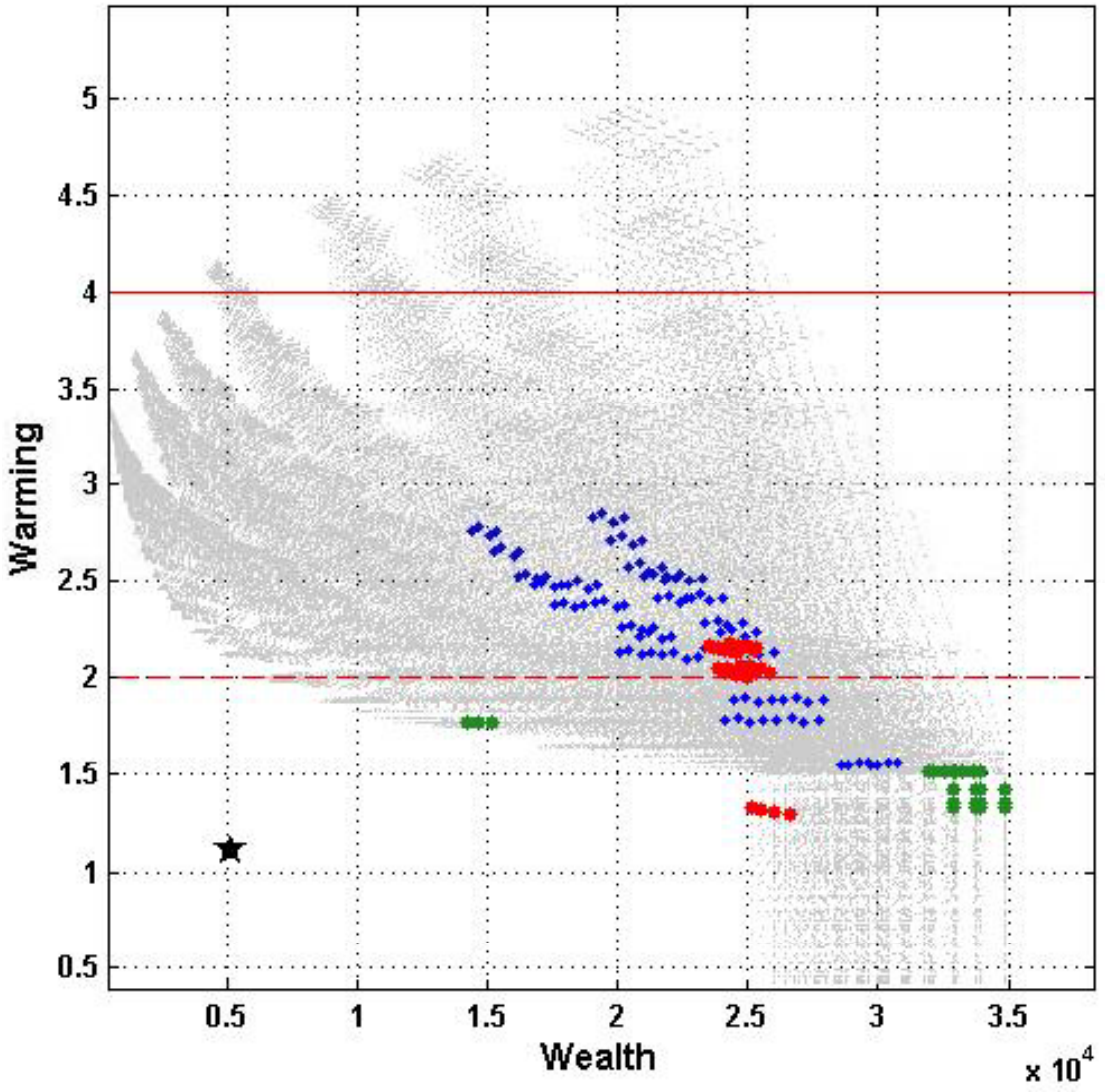
- **Level of mitigation**: How much should we reduce the human global emissions by?
- **Speed of mitigation:** By when?
- **Cost:** How much can we afford to pay?


People
Model behaviour
E
x 10^in
P
A/P
x 10^-4
Activity
Environment

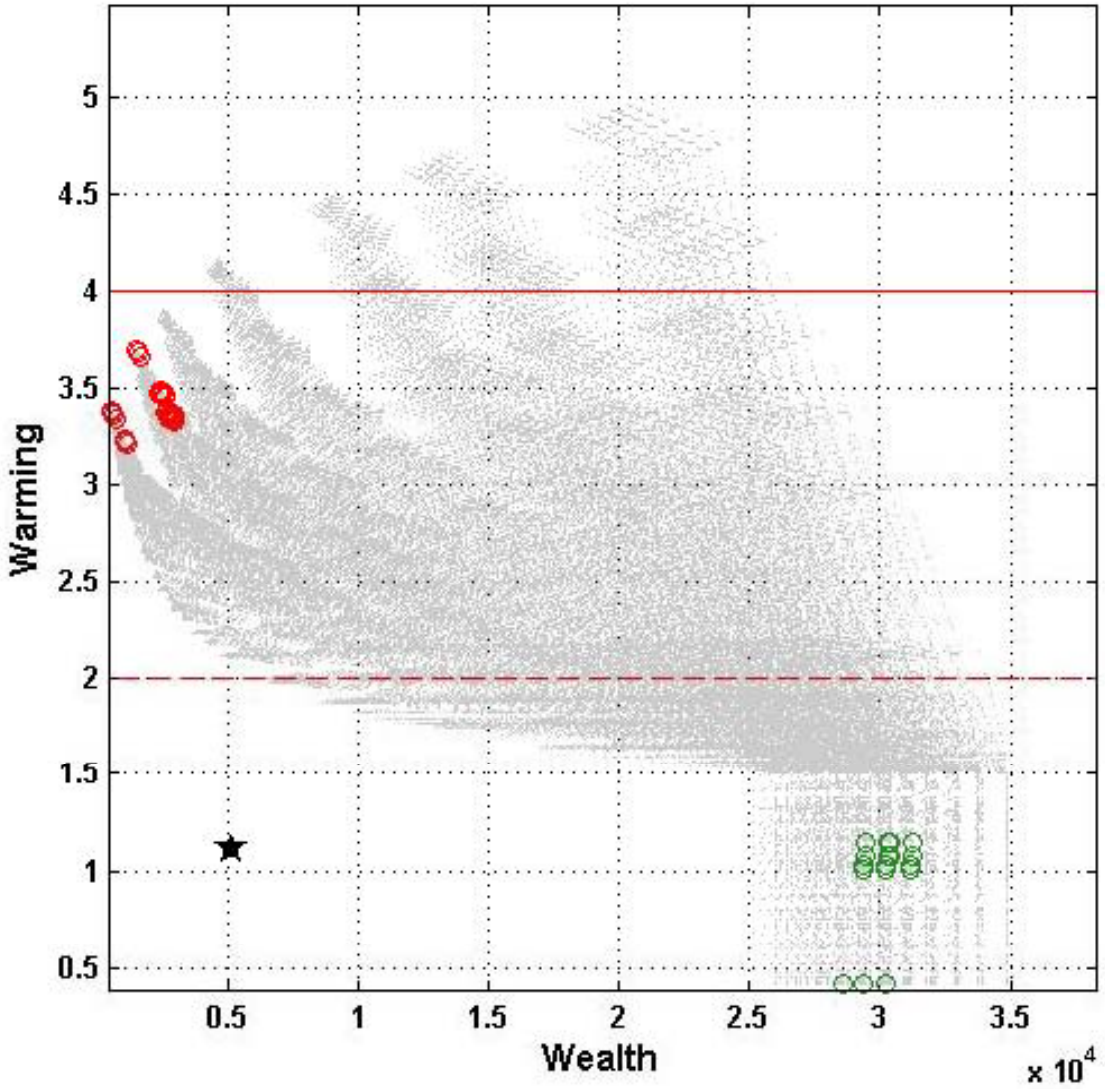
Market-centric
Moderates
Eco-centric



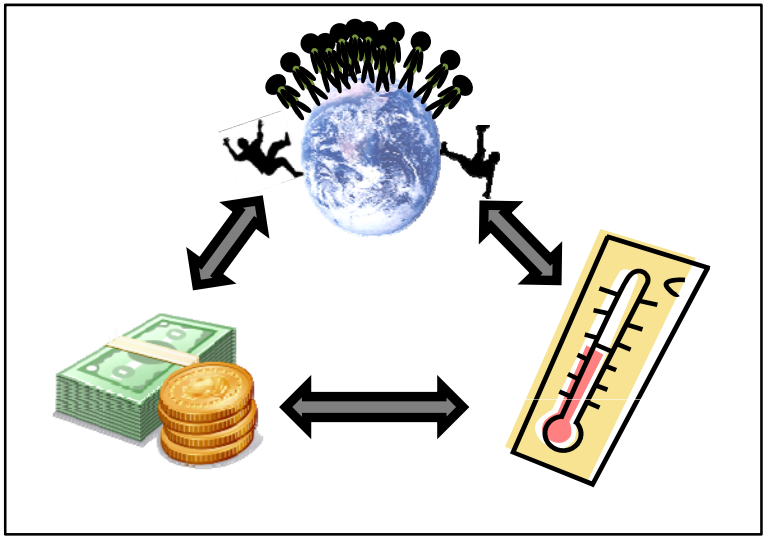
Market-centric
Moderates
Eco-centric

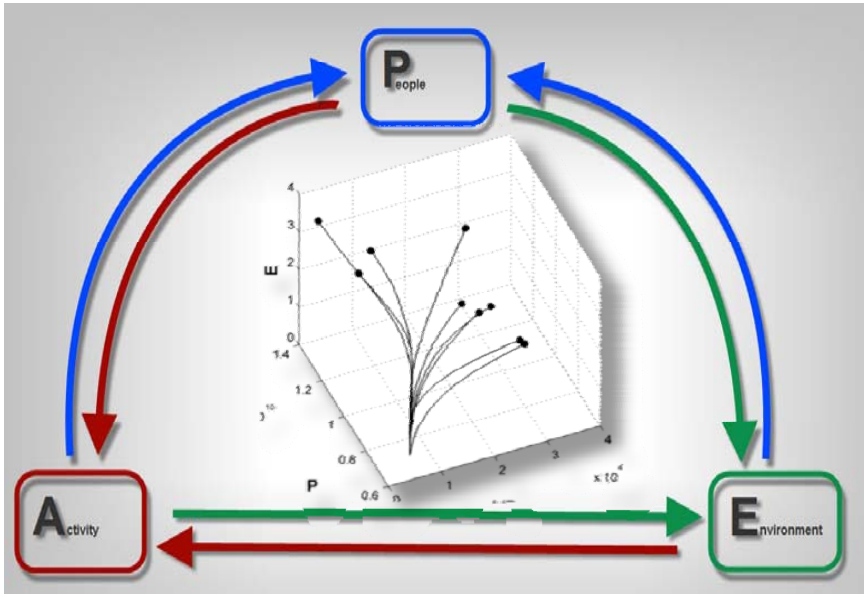


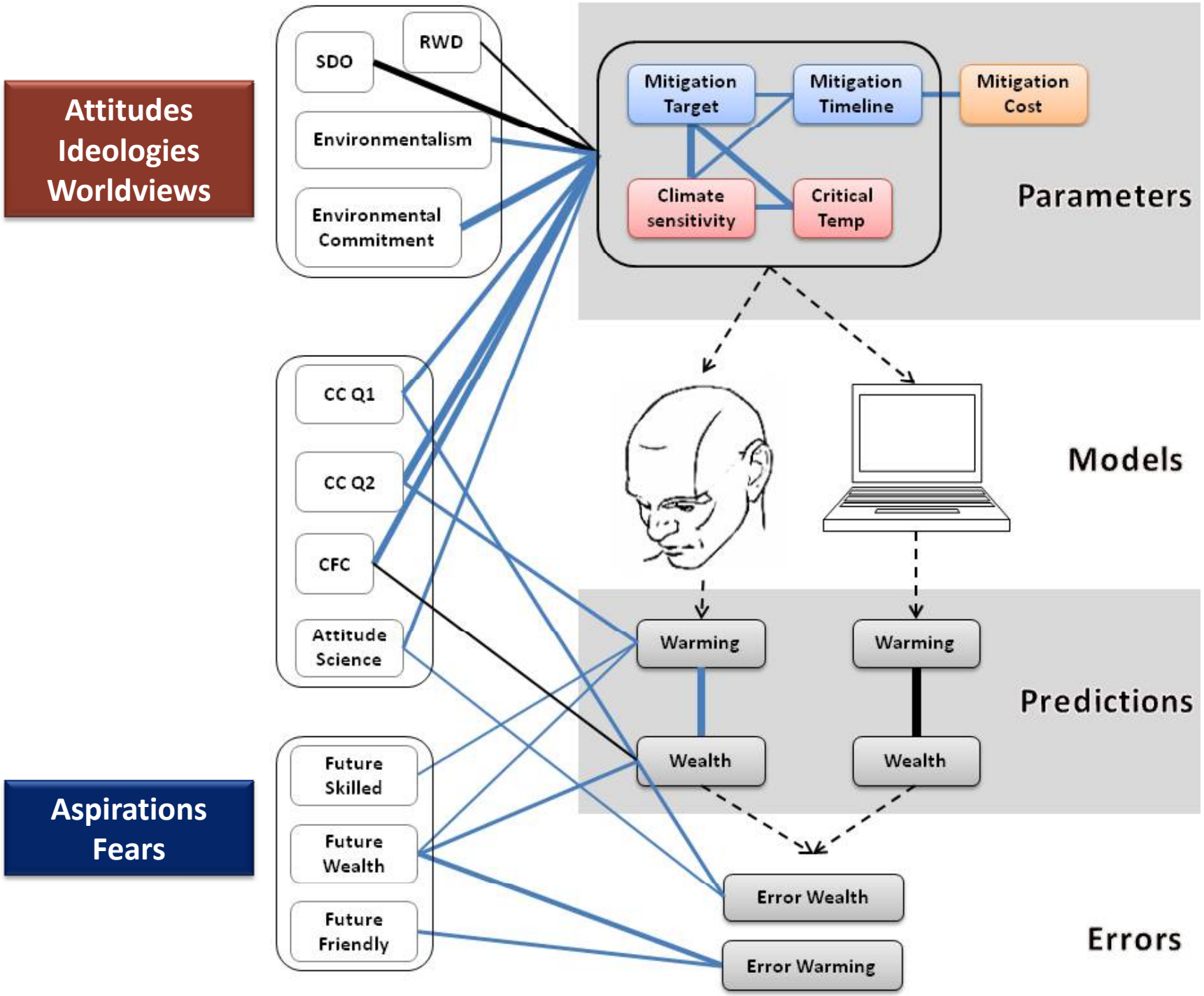
Market-centric
Moderates
Eco-centric

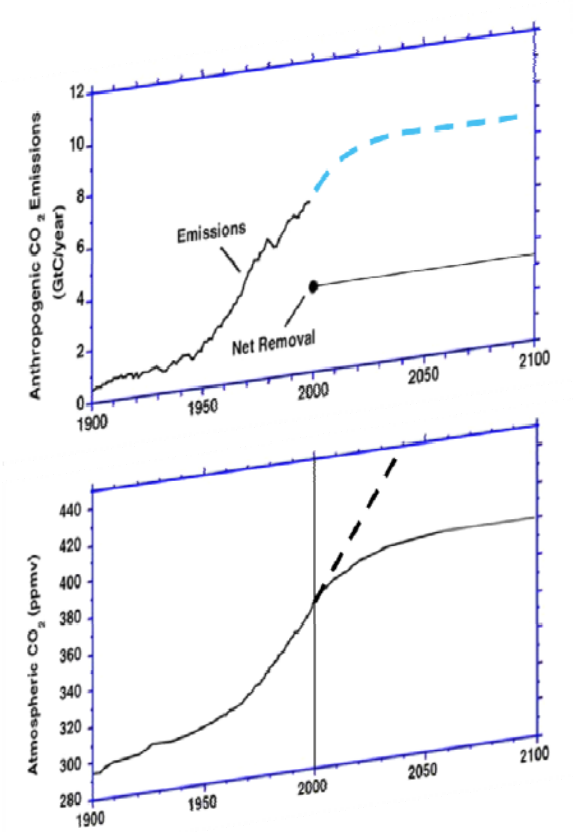


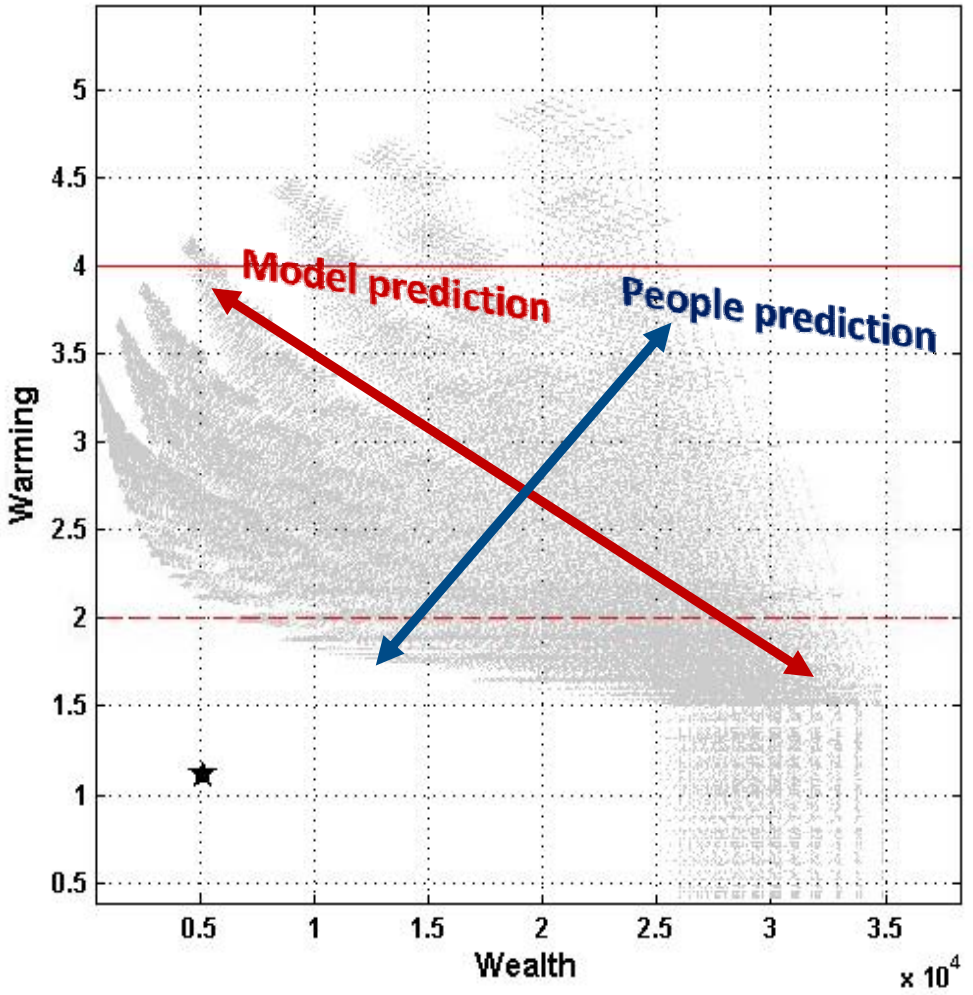

?
?

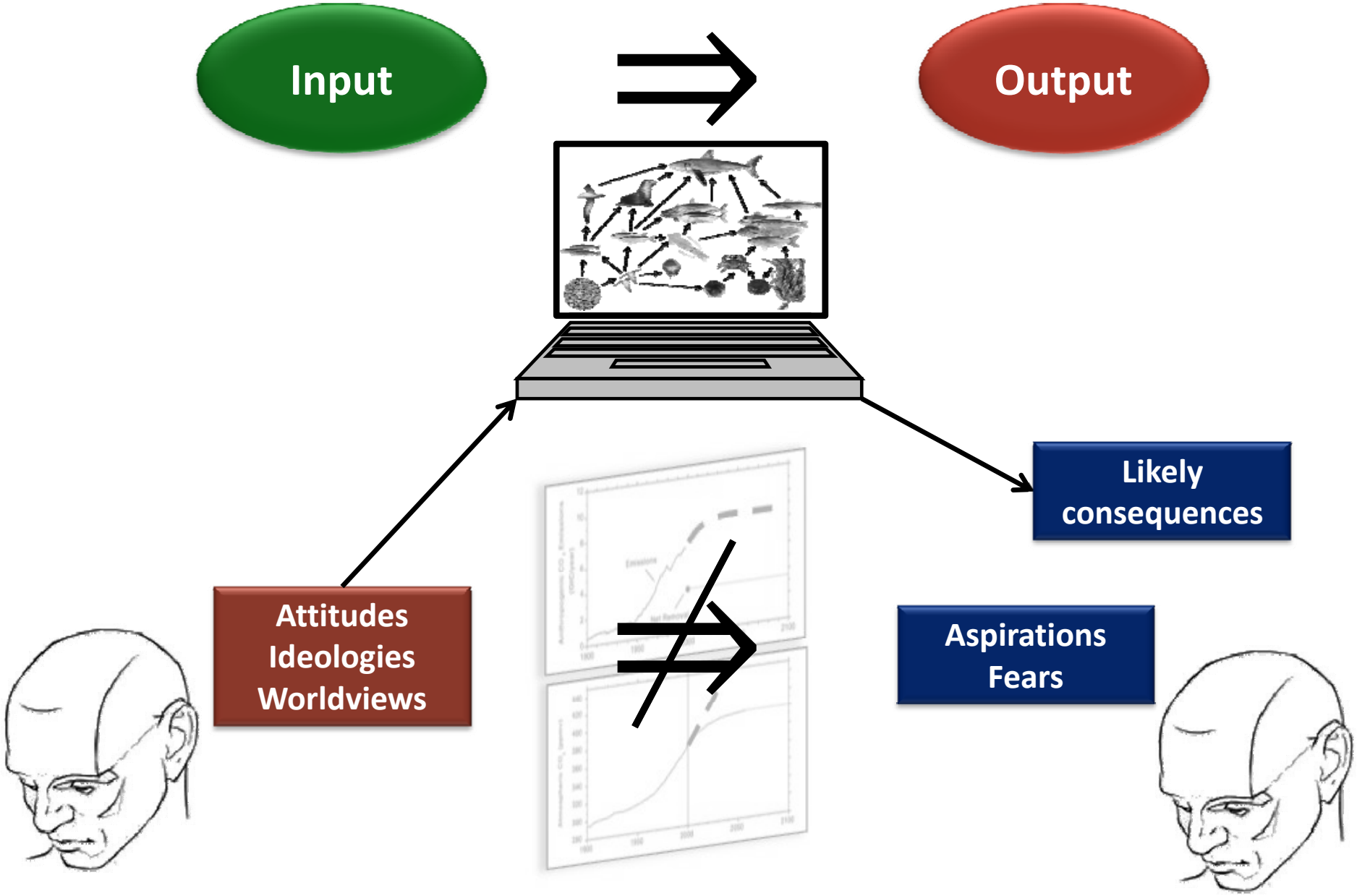



People
Activity
Environment

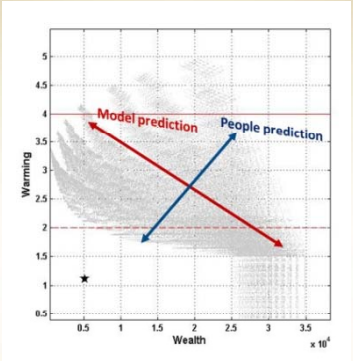

Attitudes
Ideologies
Worldviews
SDO
RWD
Environmentalism
Environmental
Commitment
Mitigation
Target
Mitigation
Timeline
Mitigation
Cost
Climate
sensitivity
Critical
Temp
Parameters
CC Q1
CC Q2
CFC
Attitude
Science
Models
Warming
Warming
Wealth
Wealth
Predictions
Aspirations
Fears
Future
Skilled
Future
Wealth
Future
Friendly
Error Wealth
Error Warming
Errors


Anthropogenic CO_2 Emissions (GtC/year)
Emissions
Net Removal
Atmospheric CO_2 (ppmv)
1900
1950
2000
2050
2100

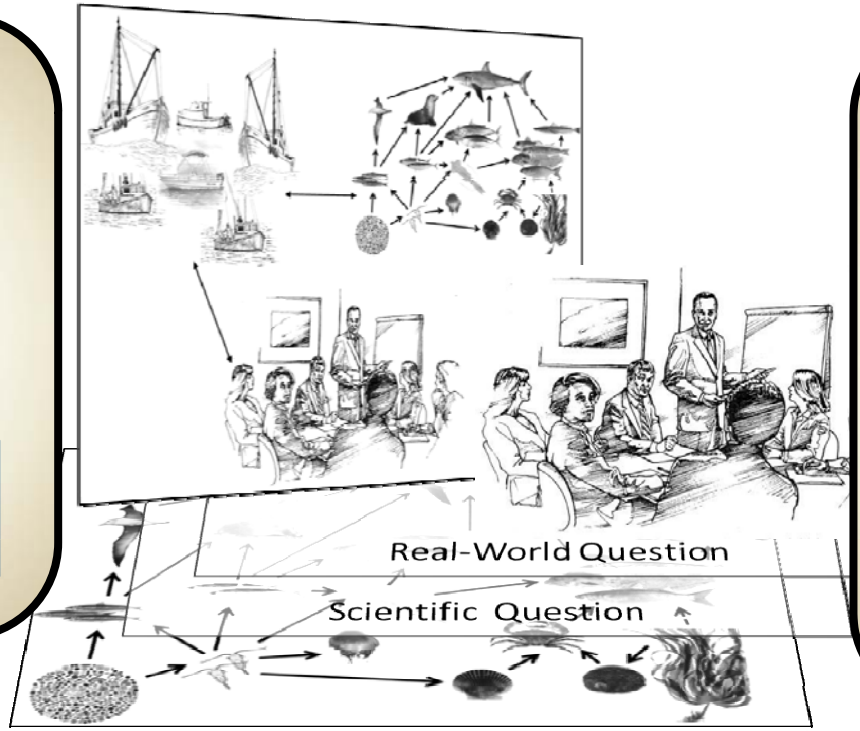

Model prediction
People prediction
Warming
Wealth
x 10^4


Input
Output
Likely consequences
Attitudes
Ideologies
Worldviews
Aspirations
Fears

2

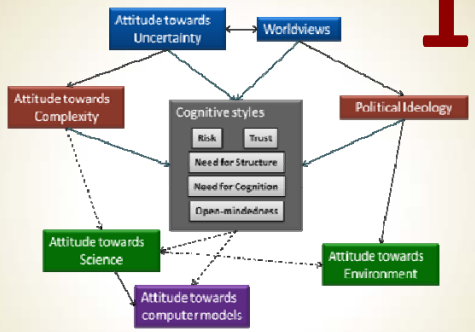


Numerical modeling of mental models



Model Understanding, Acceptance, Trust

1



Complexity & Cognitive styles

Relation between mental and numerical models

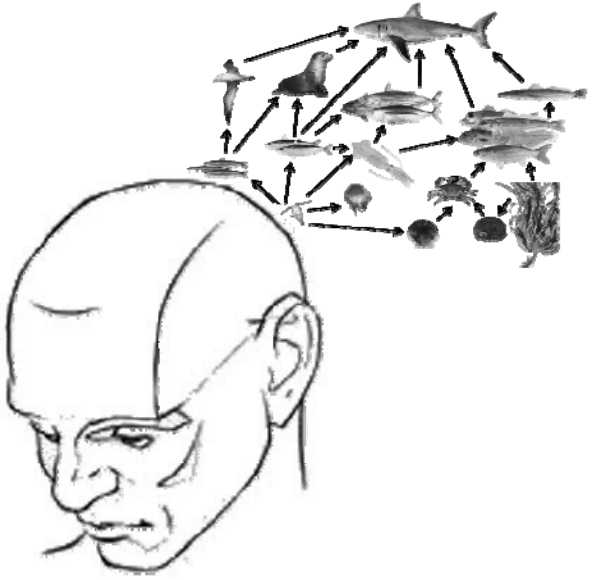
3

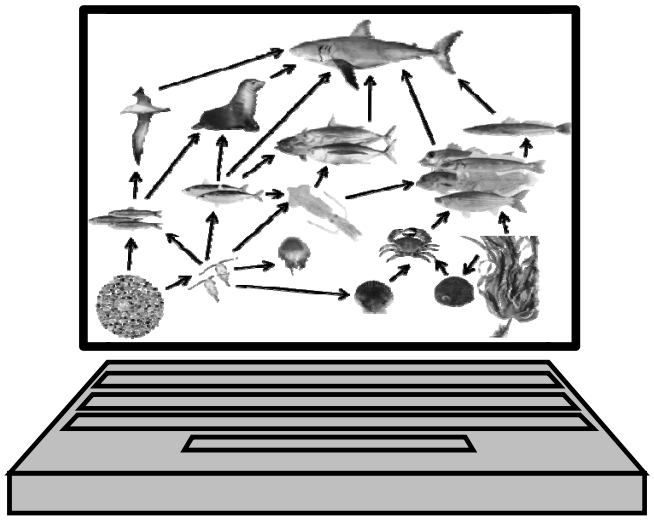
Emergence & Causation

Mental representation of reality

Numerical representation of reality

Which representation is more ‘effective’?

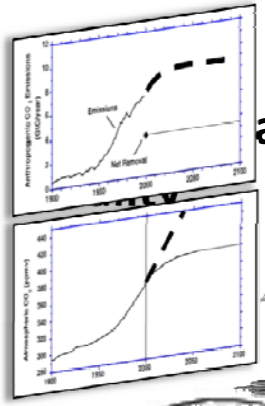


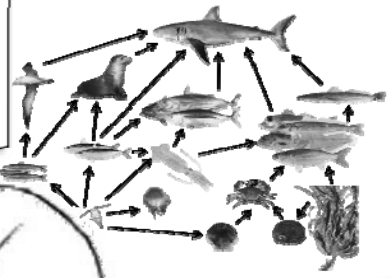


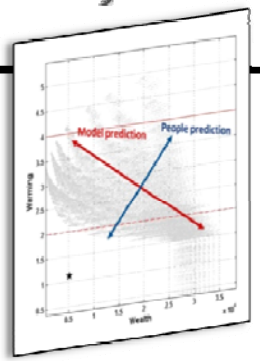
ation of

Which representation minimizes the dynamics more accurately?

Numerical representation of mental model

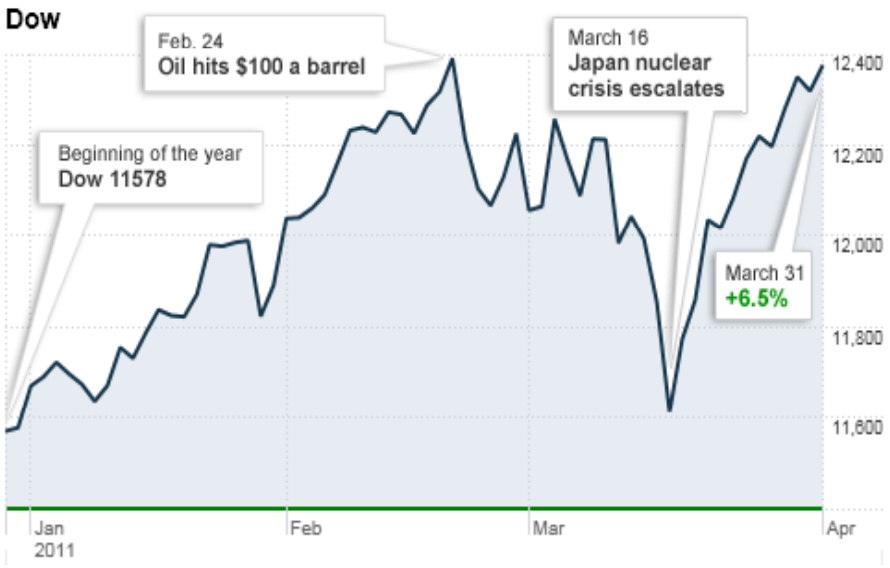


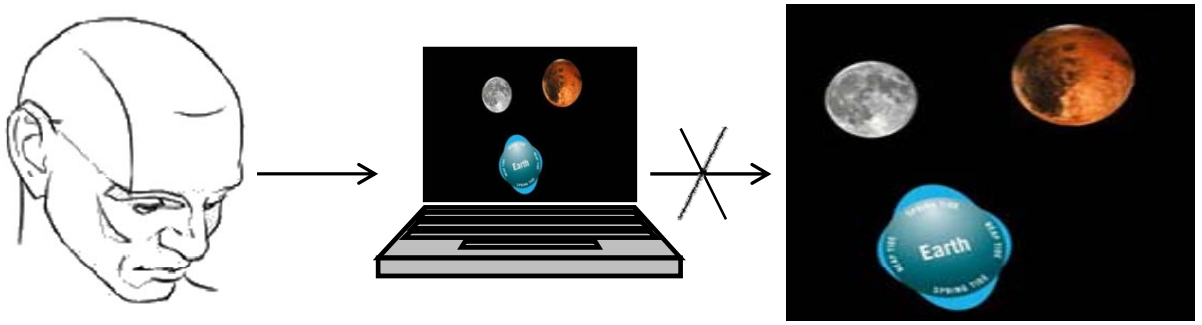


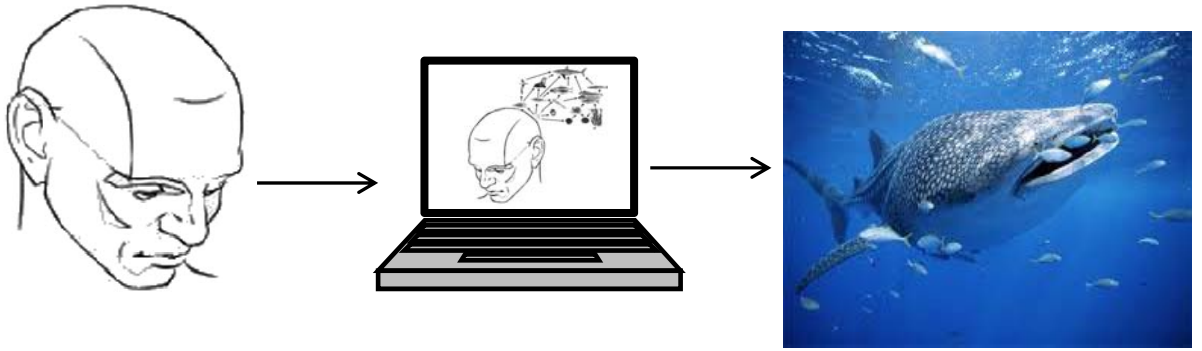


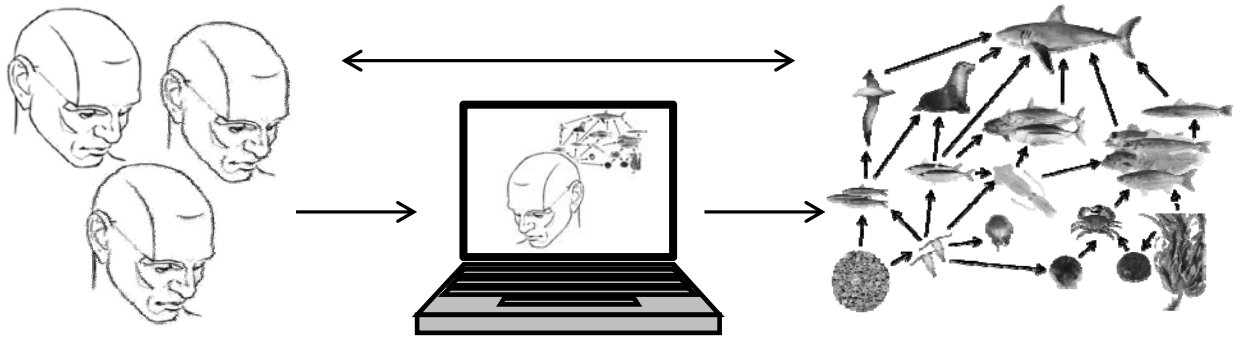
Emergence definitions from Computational mechanics

- **Pattern Recognition**
- **Efficiency of prediction**
- **Intrinsic emergence**
- **Emergence of causal power**




Earth





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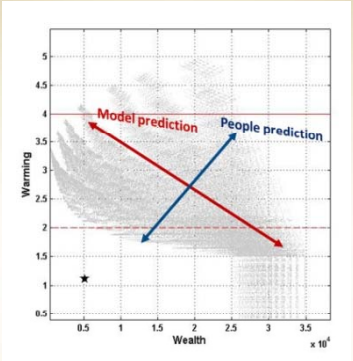

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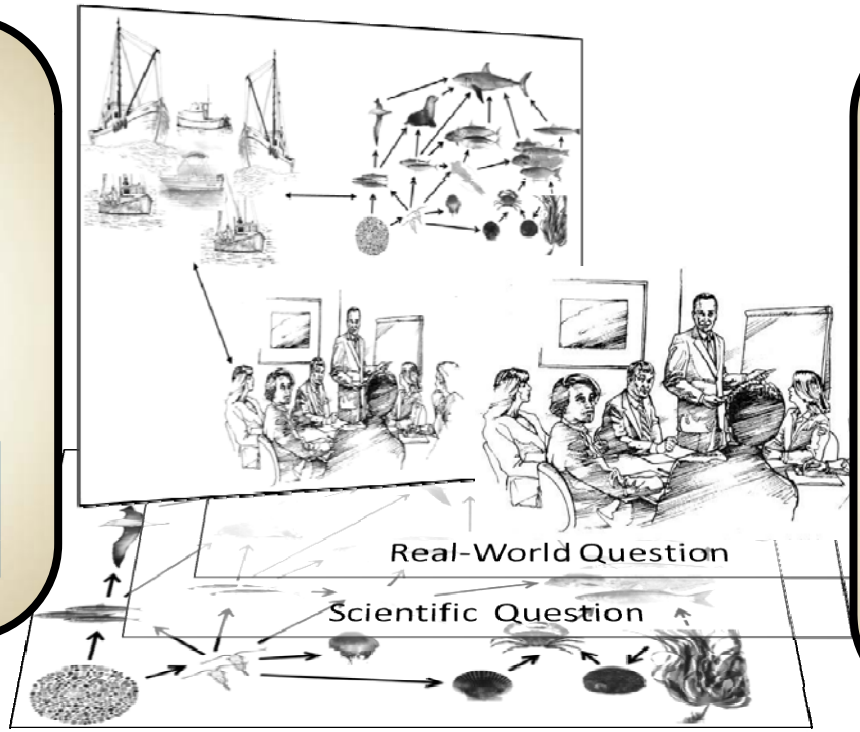

Model Understanding, Acceptance, Trust

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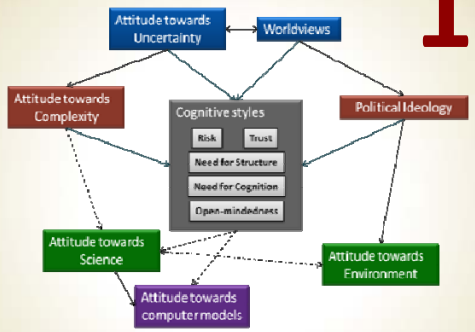

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Emergence & Causation

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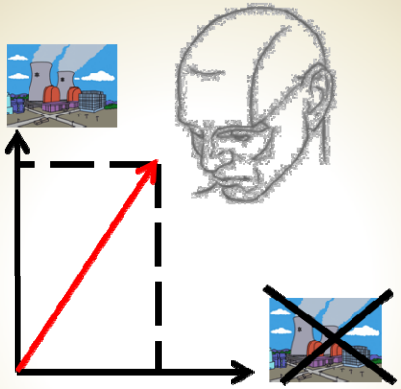
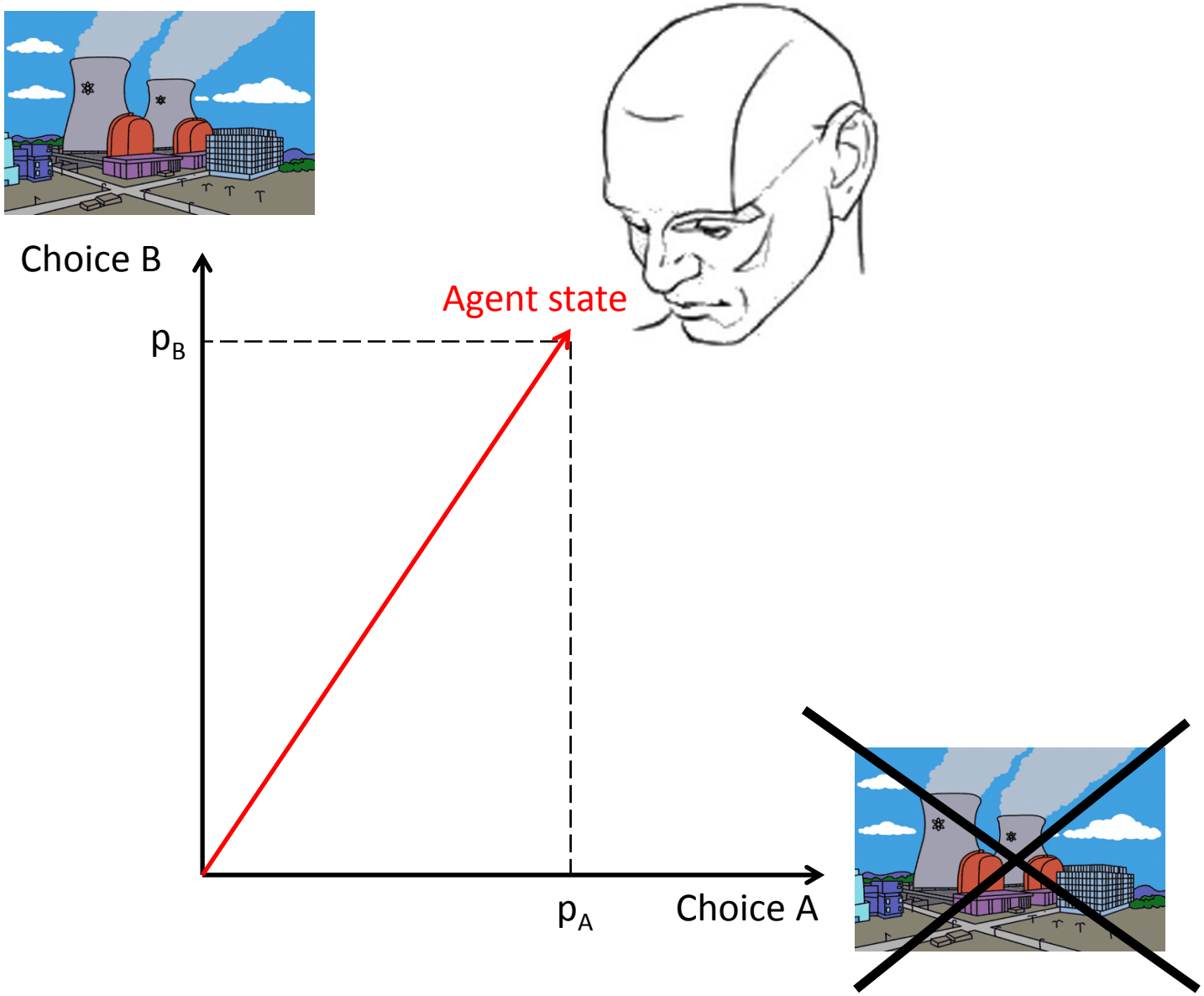
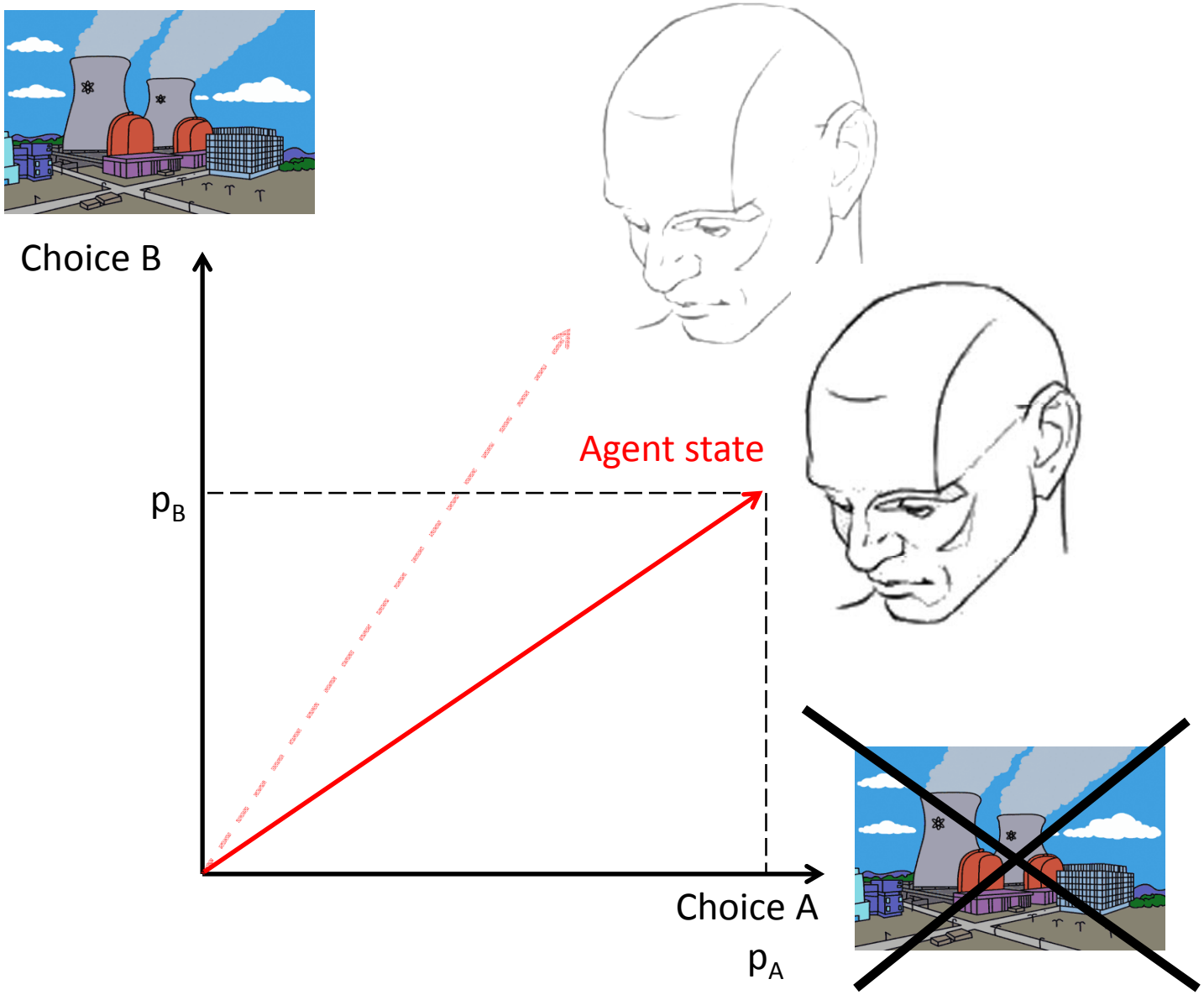
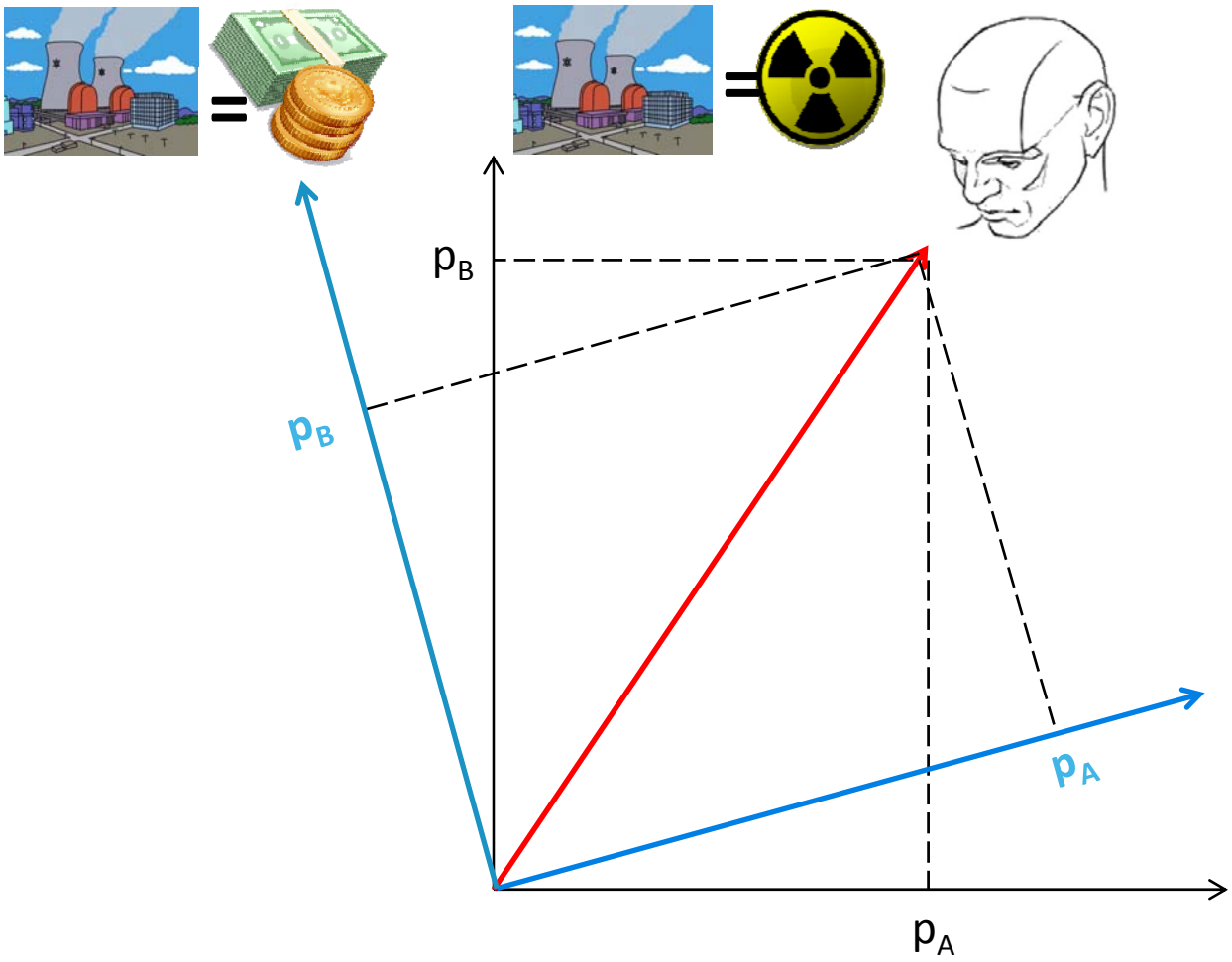
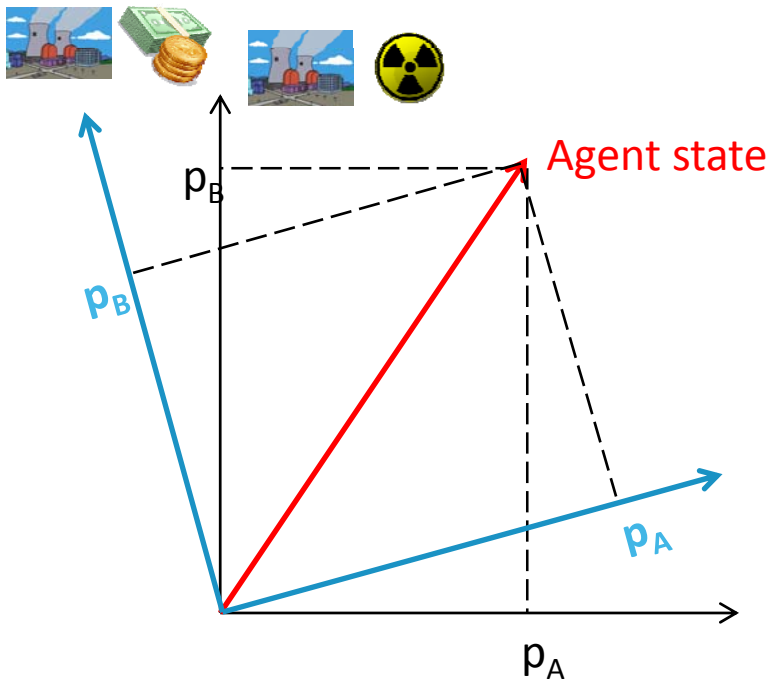


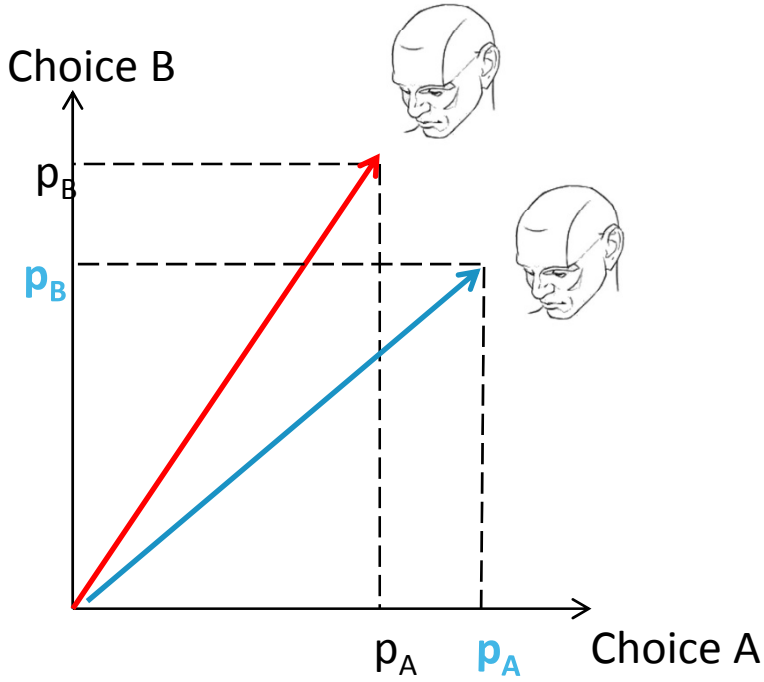
Attitudes, ideologies and self-organisation


Choice B
Agent state
p_B
p_A
Choice A

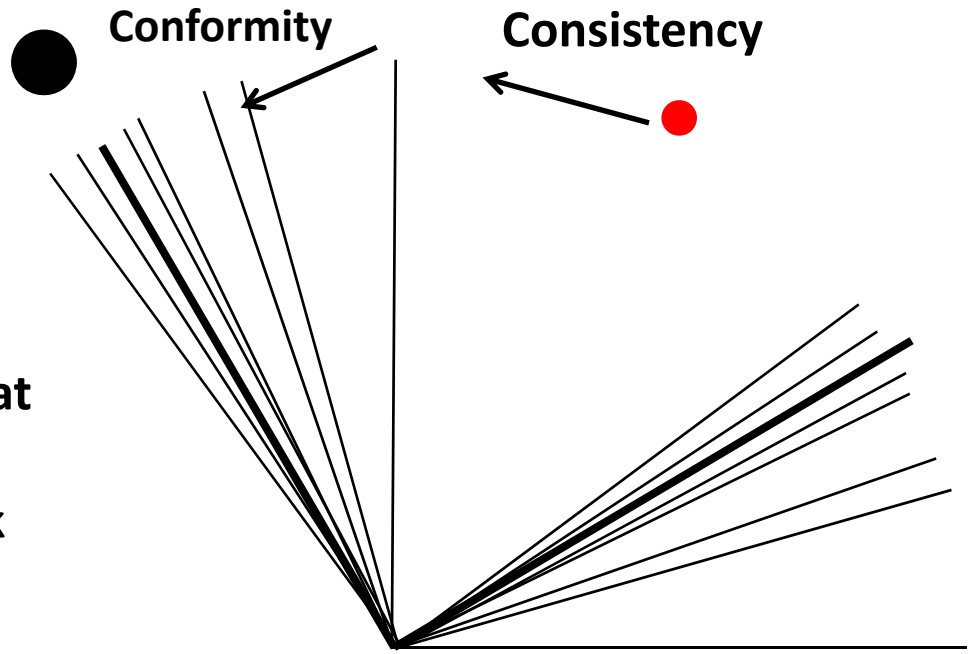

Choice B
Agent state
p_B
Choice A
p_A


p_B
p_B
p_A
p_A

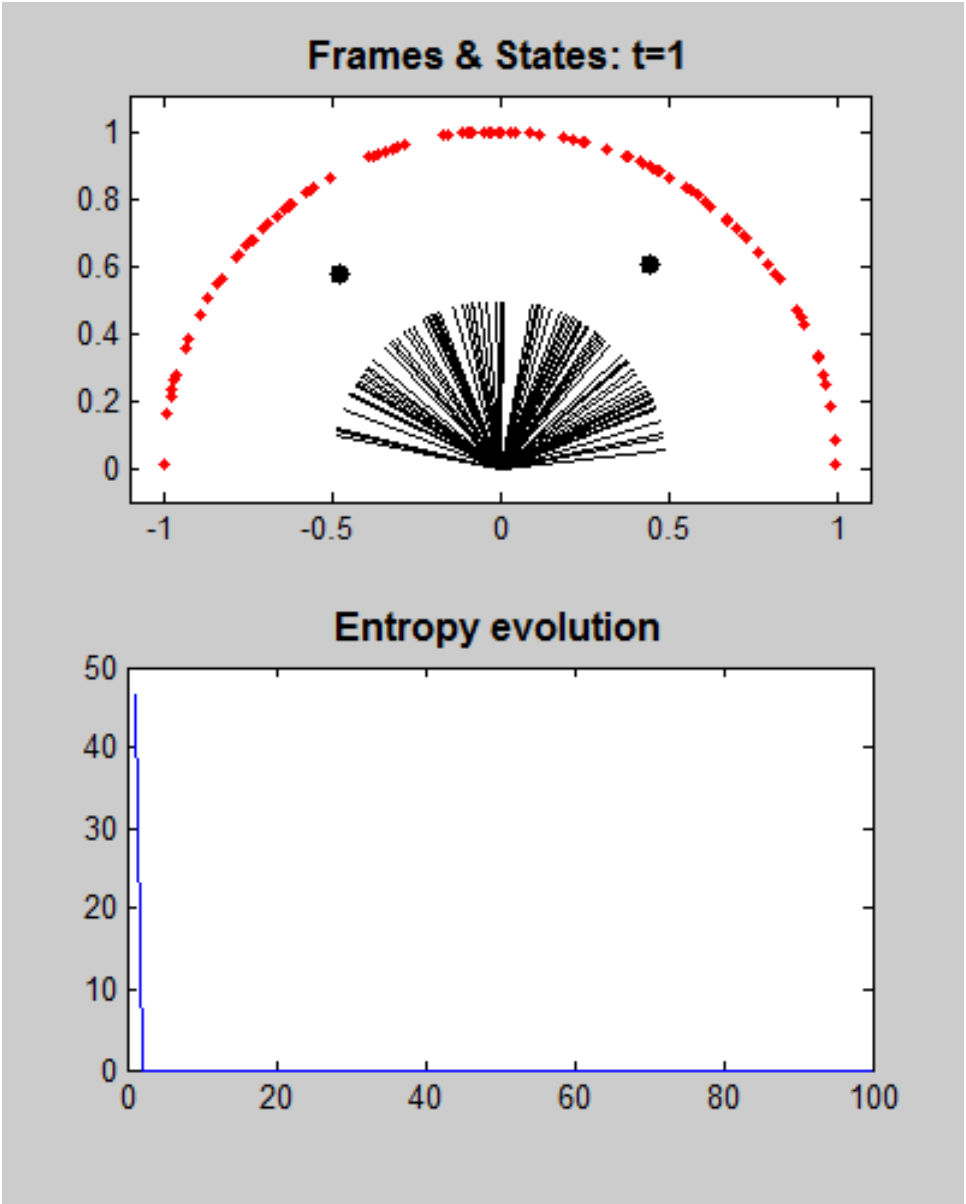

Agent state
p_B
p_B
p_A
p_A

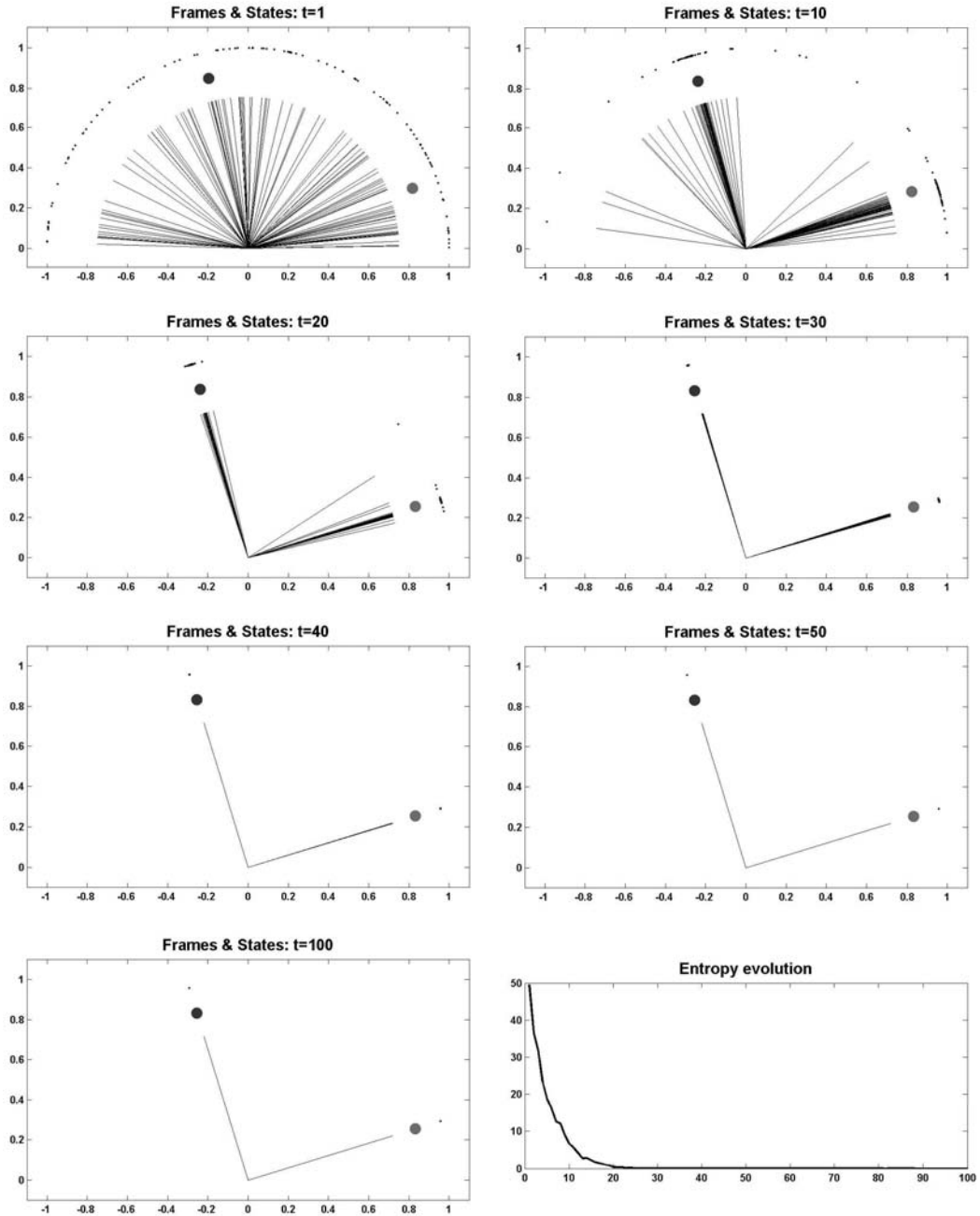

Choice B
p_B
p_B
p_A
p_A
Choice A

A ‘party’ is what most of its members think

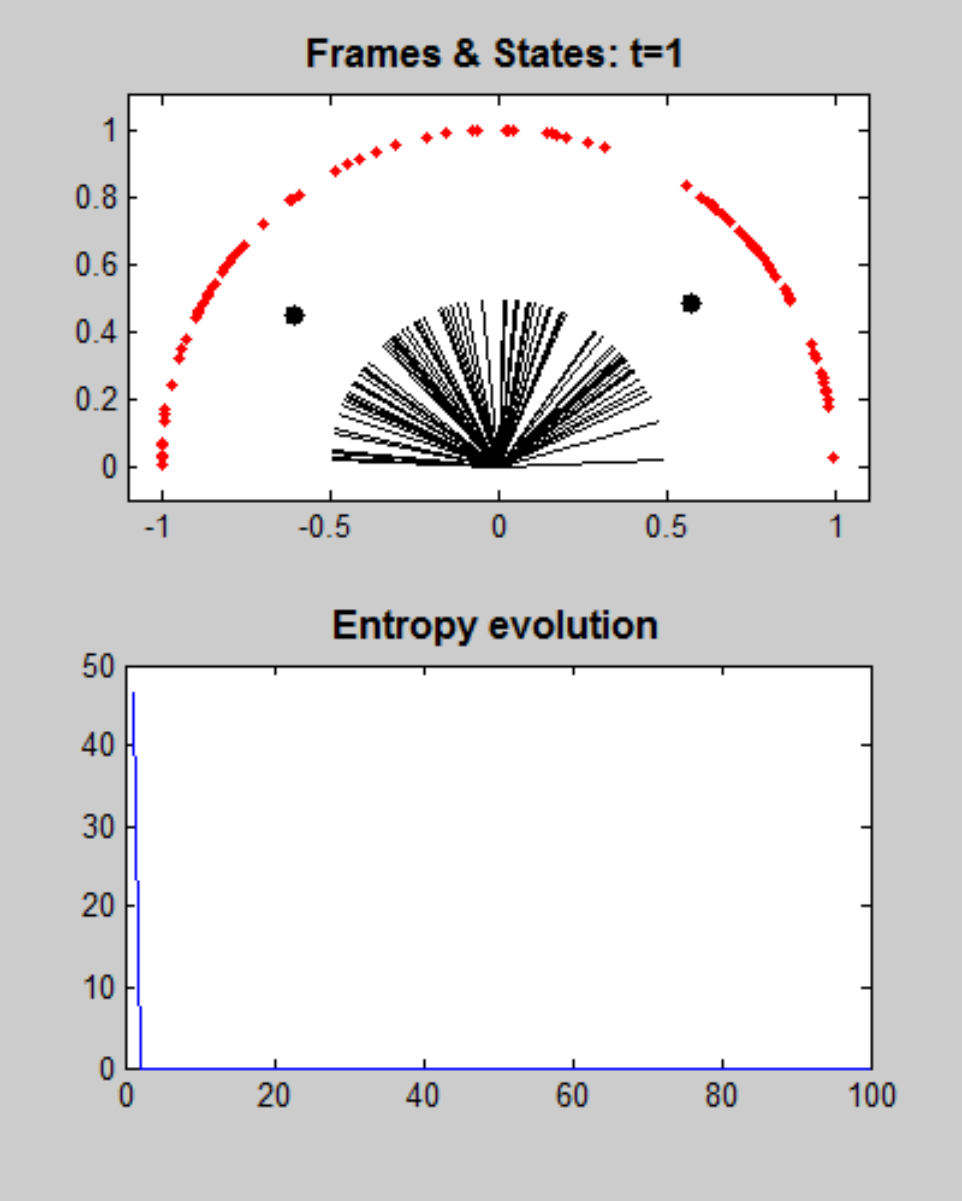


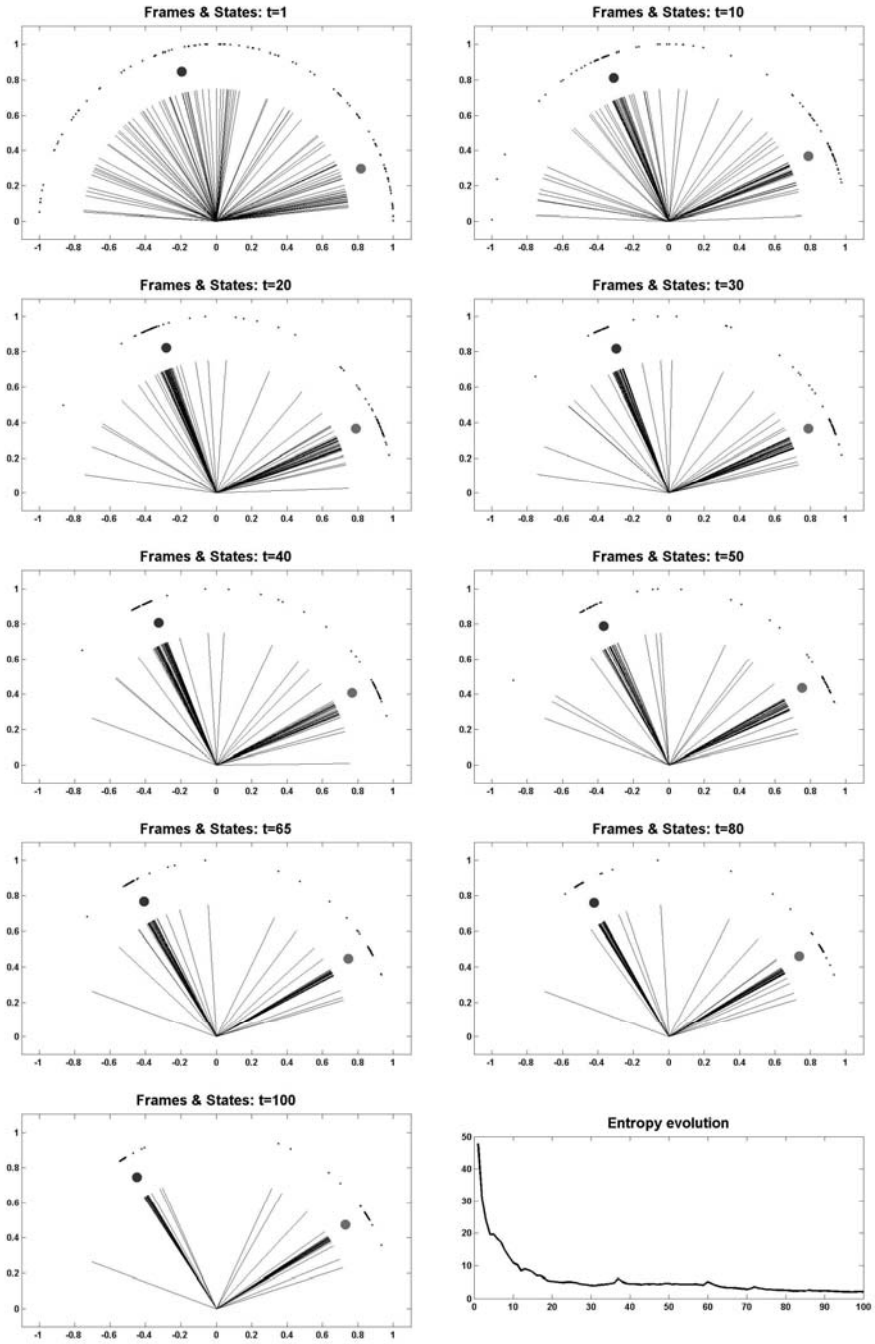
Fixed Personalities

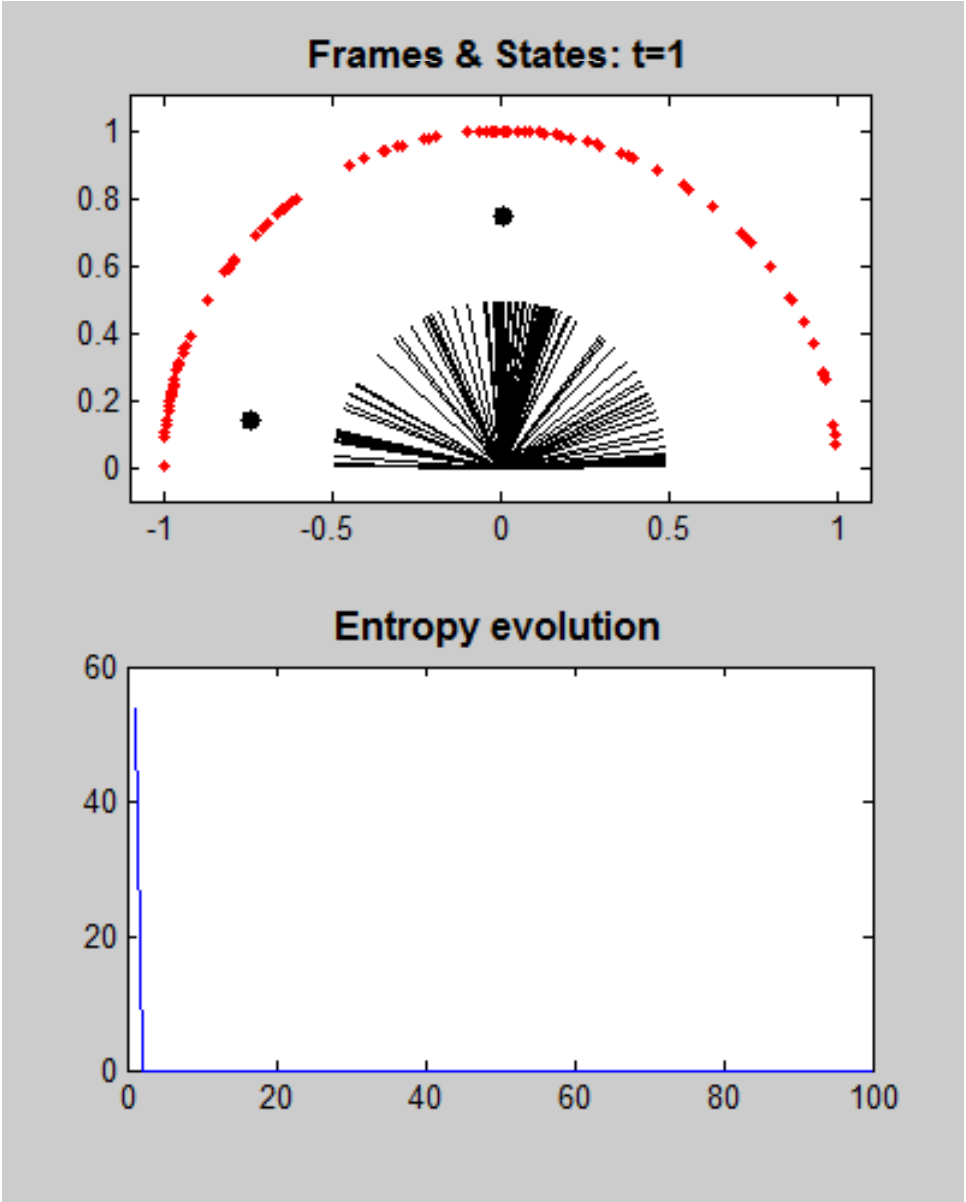


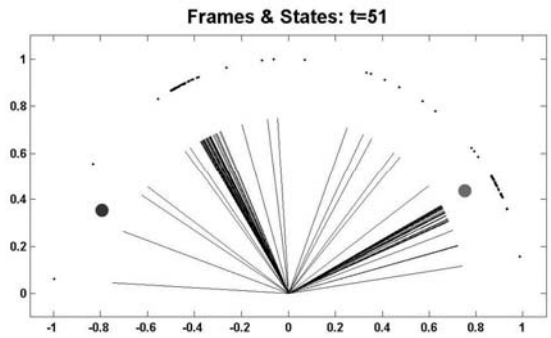

Frames & States: t=1
Frames & States: t=10
Frames & States: t=20
Frames & States: t=30
Frames & States: t=40
Frames & States: t=50
Frames & States: t=100
Entropy evolution

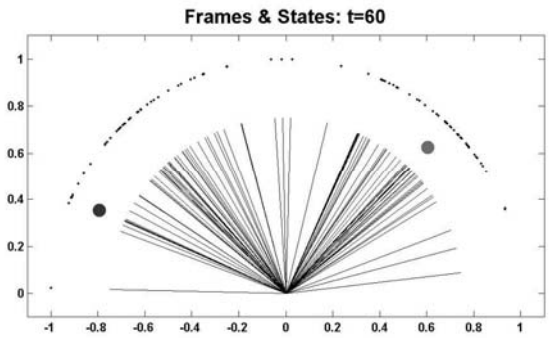
Random Personalities




Frames & States: t=1
Frames & States: t=10
Frames & States: t=20
Frames & States: t=30
Frames & States: t=40
Frames & States: t=50
Frames & States: t=65
Frames & States: t=80
Frames & States: t=100
Entropy evolution


Frames & States: t=1
1
0.8
0.6
0.4
0.2
0
-1
-0.5
0
0.5
1
Entropy evolution
60
40
20
0
0
20
40
60
80
100


Frames & States: t=51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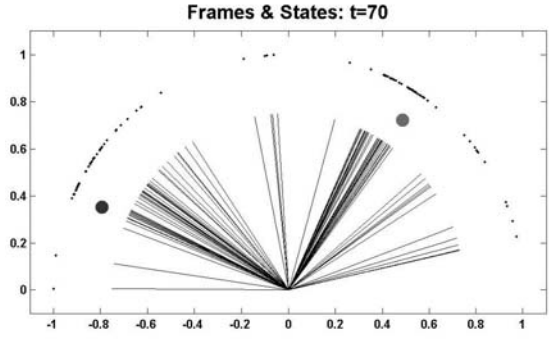
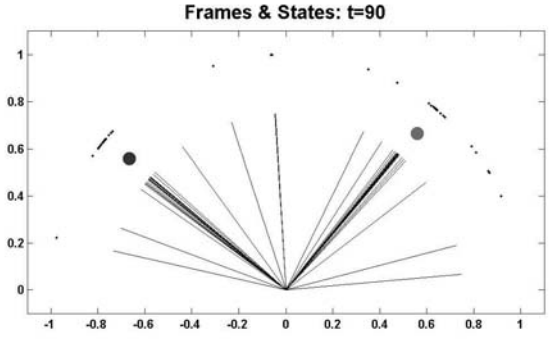

Frames & States: t=70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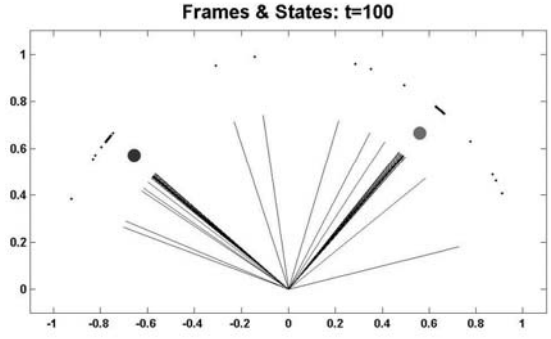
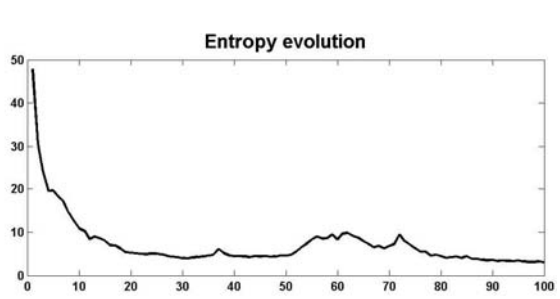
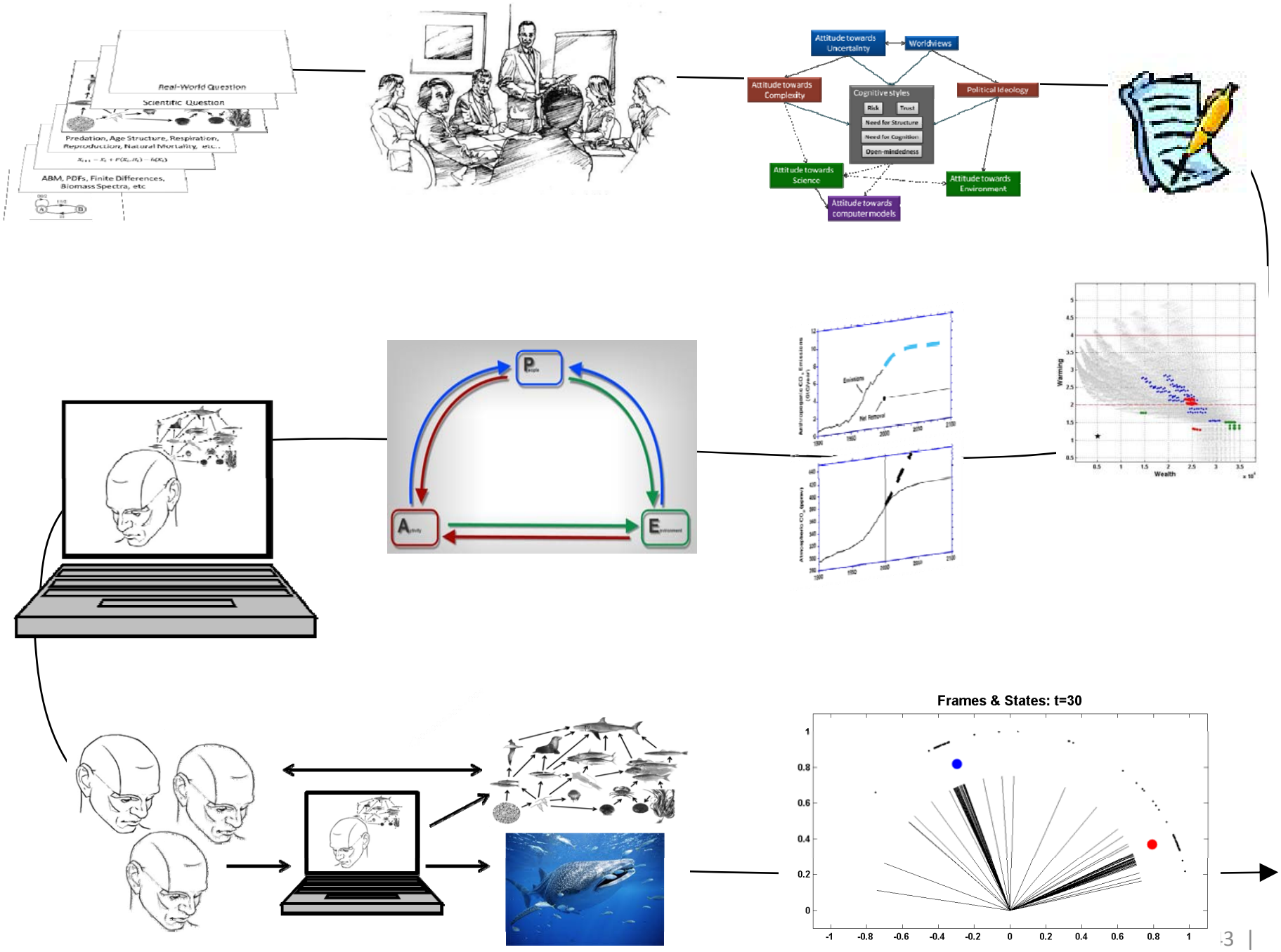

Frames & States: t=100


Entropy evolution


Real-World Question
Scientific Question
Predation, Age Structure, Respiration, Reproduction, Natural Mortality, etc...
ABM, PDFs, Finite Differences, Biomass Spectra, etc
Attitude towards Uncertainty
Worldviews
Attitude towards Complexity
Cognitive styles
Risk
Trust
Need for Structure
Need for Cognition
Open-mindedness
Political Ideology
Attitude towards Science
Attitude towards Environment
Attitude towards computer models
P
A
E
Emissions
Net Removal
Warming
Wealth
Frames & States: t=30

Modelling Purpose	Model Type
Predict/Retrodict	
Understand system functioning	
Understand causal relations	
Explore system behaviour	
Build tools for others to use	
Train specific skills and develop useful learning attitudes;	
Foster communication and collaboration.