Systems and Complexities

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References:

1. Sterman, John D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World.* McGraw-Hills. Chapter 1.

Policy Resistance

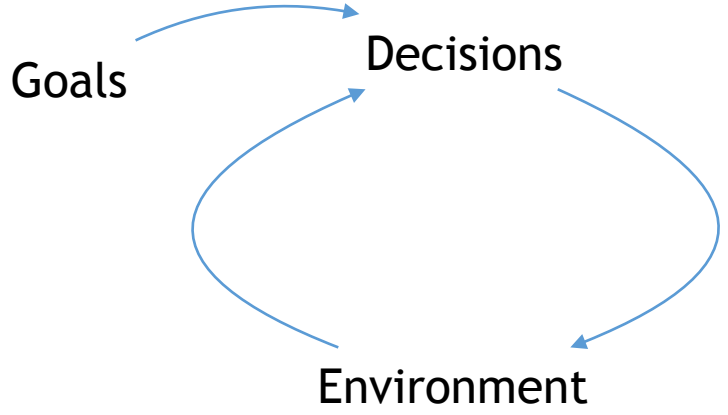
- It has long been acknowledged that people seeking to solve a problem often make it worse
  - Our policies may create unanticipated side effects.
  - Our attempts to stabilize the system may destabilize it.
  - Our decisions may provoke reactions by others seeking to restore the balance we upset.
- Forrester (1971a) calls such phenomena the “counterintuitive behavior of social systems”
- These unexpected dynamics often lead to policy resistance, the tendency for interventions to be delayed, diluted, or defeated by the response of the system to the intervention itself (Meadow 1982)

Examples of Policy Resistance

- Use of cheaper drugs pushes costs up, not down, study finds: limiting what is prescribed, as managed-care systems do, has unintended effect of increasing costs, results show
- Information technology has not enabled the “paperless office”, paper consumption per capita is up.
- Road building programs designed to reduce congestion have increased traffic, delays, and pollution.
- Pesticides and herbicides have stimulated the evolution of resistant pests and weeds, killed off natural predators, and accumulated up the food chain to poison fish, birds, and possibly humans.

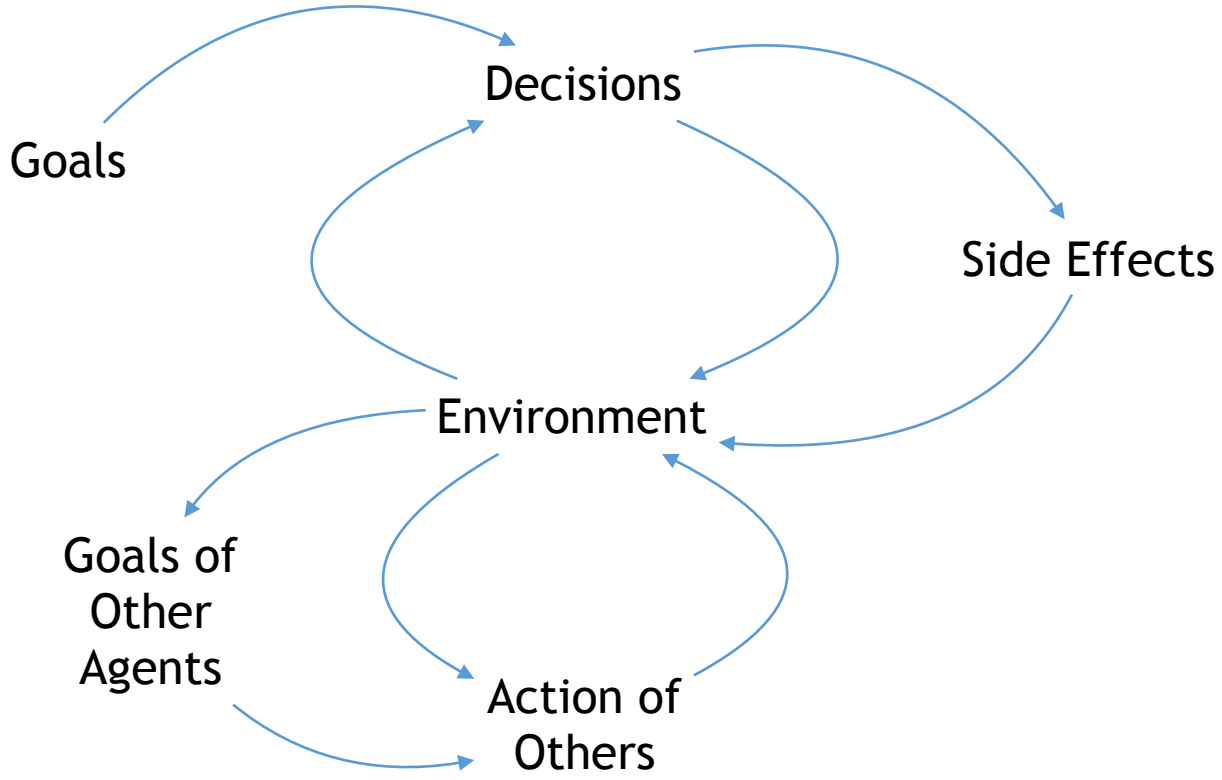
Causes of Policy Resistance

- **Yesterdays' solution becomes today's problem.**
- There is feedback: the results of our actions define the situation we face in the future
- Policy resistance arises because we often do not understand the full range of feedbacks operating in the system.
- As our actions alter the state of the system, other people react to restore the balance we have upset.



Causes of Policy Resistance (2)

- Our actions may trigger effects:
  - intended effects (beneficial)
  - side effects (the effects we didn't anticipate):
    - delayed reactions
    - changes in goals and interventions by others

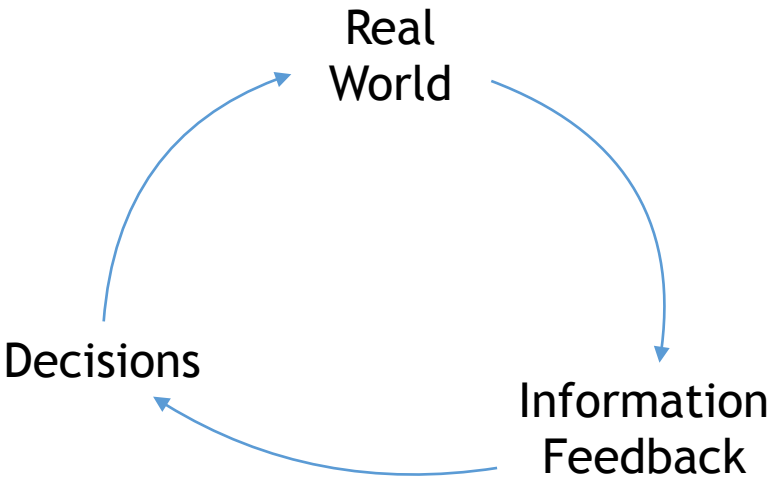


Feedback

- Most complex behaviors usually arise from the interactions (feedback) among the components of the systems
- Two types of feedback:
  - Positive feedback (self-reinforcing): tend to reinforce or amplify whatever is happening in the system
  - Negative feedback (self-correcting): counteract and oppose change: tend to be self-limiting, processes that seek balance and equilibrium.

Learning is a Feedback Process

- Just as dynamics arise from feedback, so too all learning depends on feedback.
  - We make decisions that alter the real world;
  - we gather information feedback about real world, and
  - using the new information, we revise our understanding of the world and the decisions we make to bring our perception of the state of the system closer to our goals



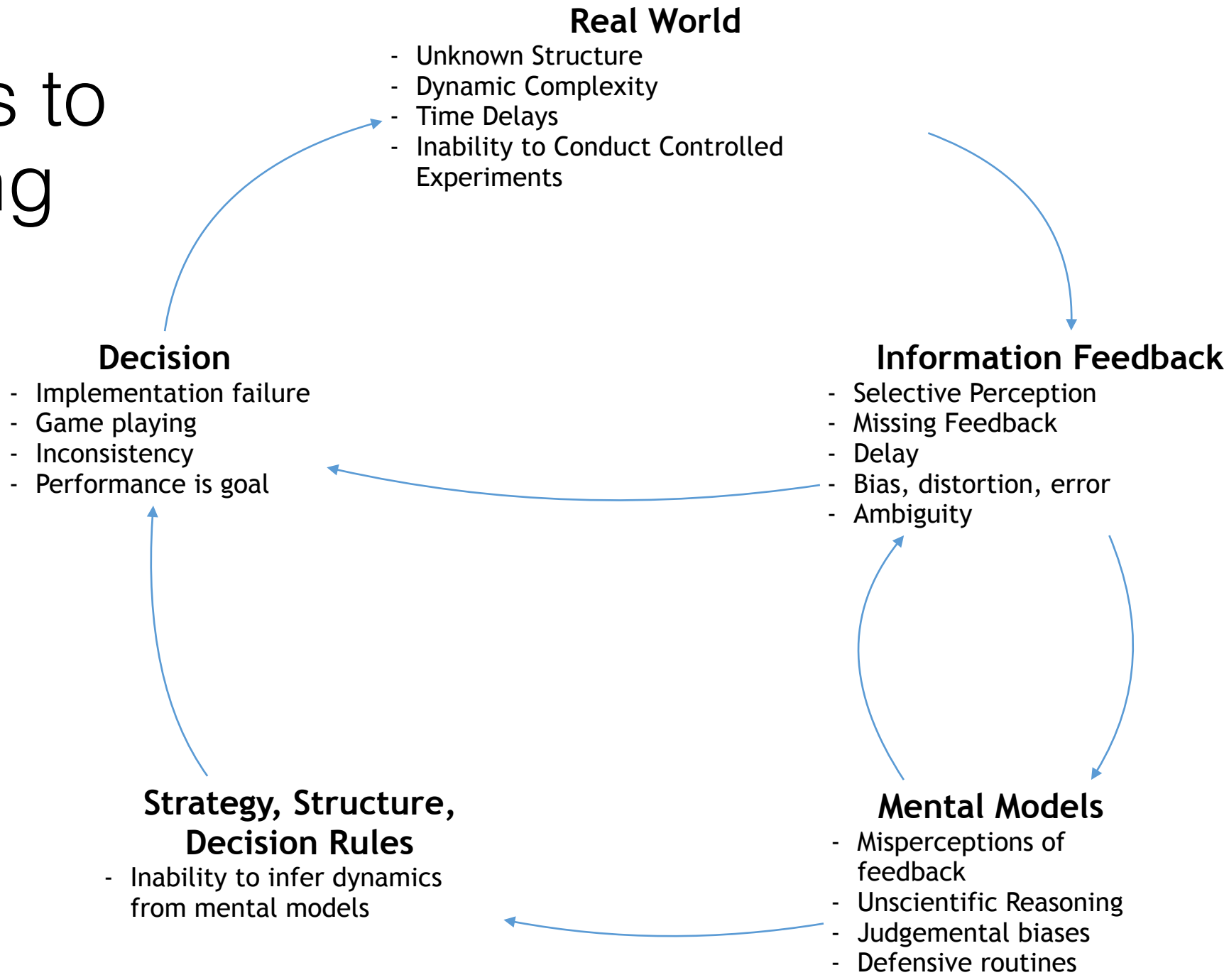
Dynamic Complexity

- Dynamic complexity can arise even in simple systems with low combinatorial complexity
- Dynamic complexity arises from the interactions among other agents over time.
- Dynamic complexity not only slows the learning loop, it also reduces the learning gained on each cycles.
  - Delays reduce the number of times one can cycle around the learning loop, slowing the ability to accumulate experience, test hypotheses, and improve.

Dynamic Complexity Arises Because Systems Are

- Dynamic
- Tightly Coupled
- Governed by Feedback
- Nonlinear
- History-dependent
- Self-organizing
- Adaptive
- Counterintuitive
- Policy Resistant
- Characterized by Trade-offs

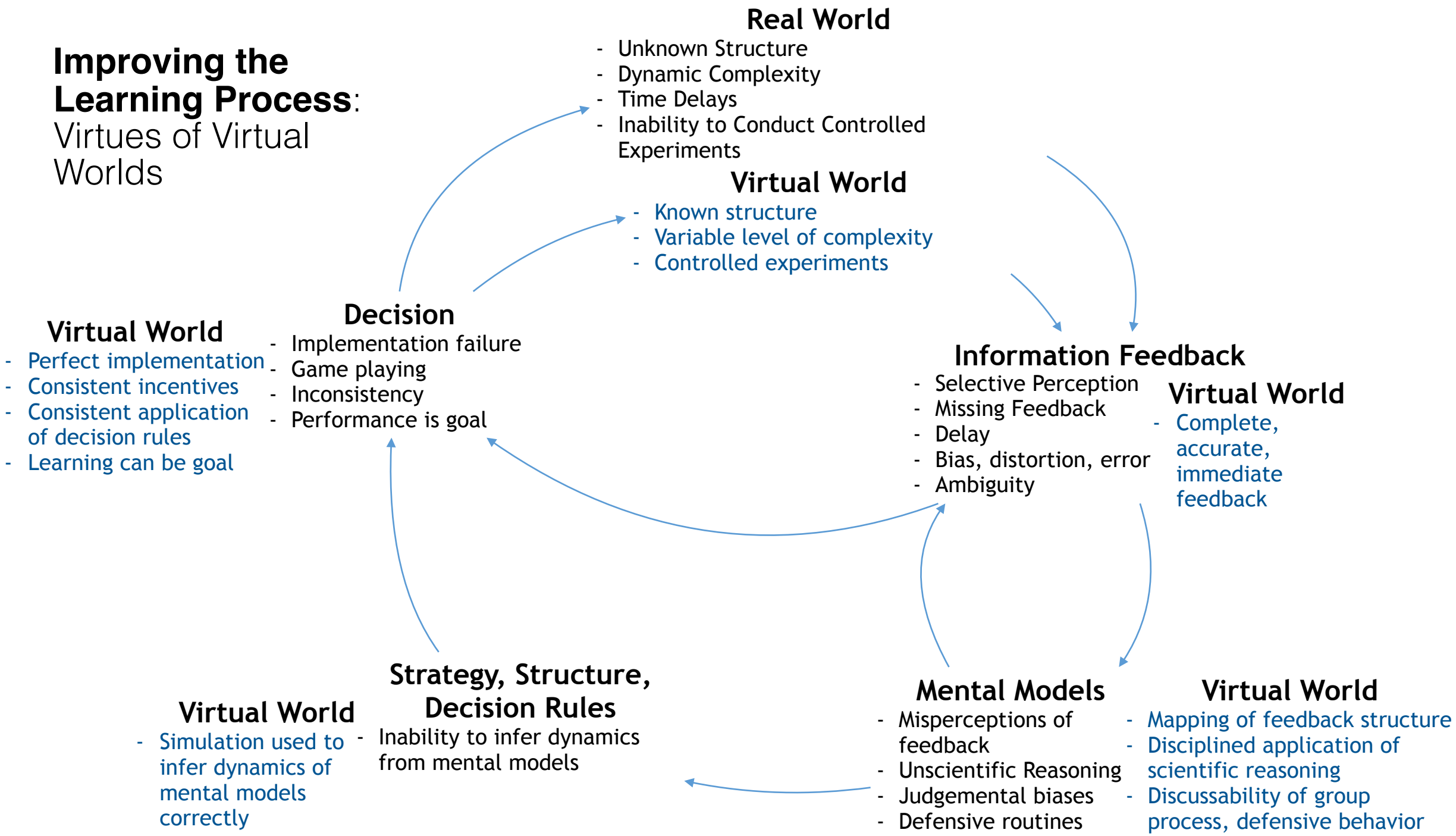
Barriers to Learning



Barriers to Learning

- Dynamic Complexity
- Limited Information
- Confounding Variables and Ambiguity
- Bounded Rationality and the Misperceptions of feedback
- Flawed cognitive maps
- Erroneous Inferences about Dynamics
- Unscientific Reasoning: Judgemental Errors and Biases
- Defensive Routines and Interpersonal Impediments to Learning
- Implementation Failure

Improving the Learning Process: Virtues of Virtual Worlds



Pitfalls of Virtual World

- Though simulation models and virtual worlds may be necessary for effective learning in dynamically complex systems, they are not sufficient to overcome the flaws in our mental models, scientific reasoning skills, and group processes.

Assignment 1: Student Exploration

- Explore an existing system:
  - Identify and define the problem.
  - Identify system environment (SoS?)
  - Determine the set of alternative solutions.
  - Determine the criterion or criteria that will be used to evaluate the alternatives.
    - Intended effects
    - Side effects
    - Information Feedbacks
  - Evaluate the alternatives.

End slides.

- Supporting resources:
  - http://www.c5.cl/ieinvestiga/actas/ribie2000/charlas/alessi.htm