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12-14 June 2007, at US Naval Academy, Annapolis, MD

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VALIDATION METHODOLOGY for AGENT-BASED SIMULATION

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ABOUT ABSVal

- ***WHICH SIMULATIONS*** **are the target of interest**
  - **Directly applicable to IW problem set**
  - **In addition to ISAAC, Pythagoras, MANA, consider decision rules, knowledge-based systems, cellular automata, population dynamics**
- **Discussion about VV&A**
  - **Goal of validation: Match Tool to Application**
    - **Conservation of Vagueness: definition of "*match*"**
- **DoD definitions & Processes**
    - **Looking at UK MOD, AIAA, ASME, NASA, DOE**
- **Two phases**
  - **This phase: What we need to know to evaluate an ABS**
  - **Next Phase: Experiment with methods**

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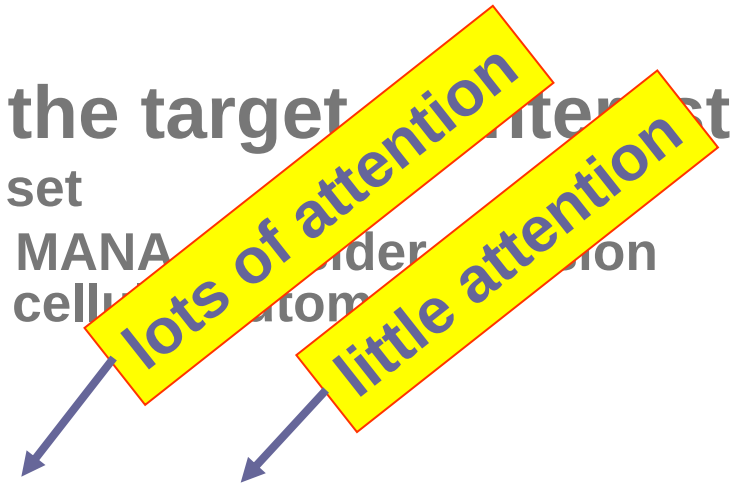


Schism

- **Agent-based simulations use modular rules and local reasoning to produce realistic and/or interesting emergent aggregate behavior.**
  - **Surprise is good**
- **Successful simulation testing (core to face/results validation) based on demonstrating credibility across the range of potential input.**
  - **Surprise not good**

** Refined later in this talk

Questions

- What activities can I reasonably support with my ABS?
- What are the limits?
- What caveats are necessary?
- Compared with traditional simulation solutions, how are my results to be used?
- How can I make credibility statements about a simulation that is out of my (top-down) control?
  - Value of training experiences
  - Value of analytical results

- <u>Can I support the scientific method with this ABS?</u>

ABSVal Products

- **General, institutionally acceptable processes and criteria for assessing the validity of an agent-based simulation used as part of a DoD-level analysis**
  - **What information?**
  - **What assurances and endorsements?**
  - **What desirable qualities?**

Benefit

- Increased awareness of the value of analysis results supported by agent based simulation(s)
- [Potential] Increased credibility of results
- [Potential] More valuable agent-based simulations
- [Potential] Responsible analytical application of ABS by OA professionals
- [Potential] Civilization of the discourse concerning ABS-generated analysis results

Benefactors: HBR, VVA, All Military Organizations using ABS, Analysis, Planning, Experimentation, Training, Acquisition, …

First Principles

GOAL OF SIMULATION

a) Aggregate effects you understand
b) Calculate probability of simultaneous/sequential events
c) Challenge user's intuition**

DATA

a) Model exists because of the data
b) Data exists because of the model
c) Accuracy, precision
d) Covering the possible truths
e) Propagating uncertainty & model sensitivity analysis

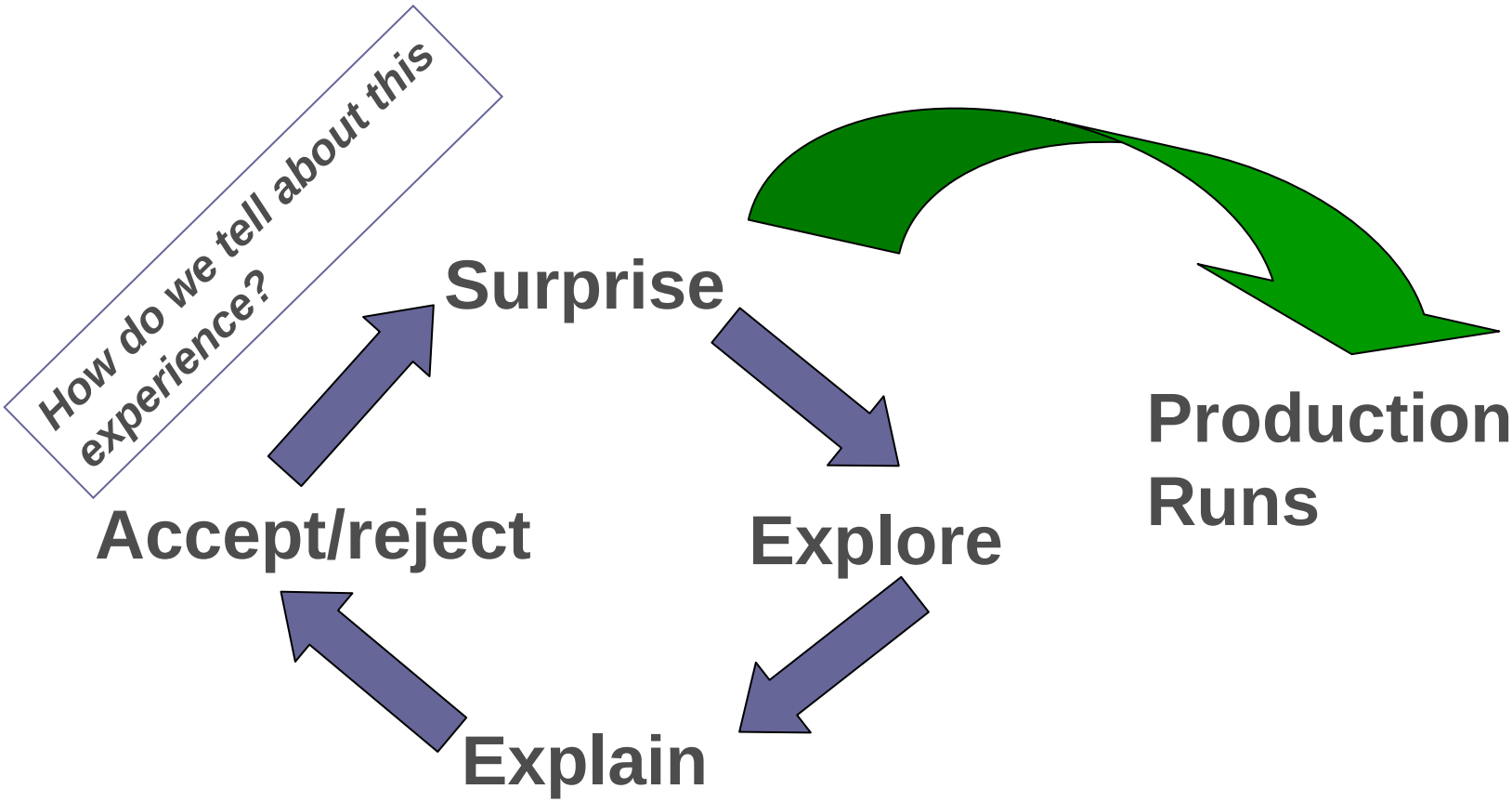
SEEING THE INSIDE AND OUTSIDE

a) Depict agent's behavior
b) Depict aggregation methods
c) Serial aggregation (building blocks)
d) Prose, pictures, diagrams, tests
e) Visualization of outcomes, trends, cause-effect

VALIDATION SURROGATES

a) History of successful uses
b) Credible believers
c) Large, mature user community
d) Transparency
e) Relative validity
f) (Over-?) Fitting historical data

Surprise!



What abstractions, data values, shortcuts, tricks, intentional oversights, modifications to expectations, code changes were required?

Representation

- **Dynamic Influence**
  - **1st-order effect**
  - **Direct influence**
  - **Relevant over large interval**
  - **Plausibly relevant over limited interval**
  - **Possibly influential**
  - **Minor detail**
  - **No relevance**
- **Distillation**
  - **Include only the highly-relevant dynamics**
  - **Aggregation of effects**
  - **Referent often loose/missing**

Completeness vs. Parsimony

Statistical Methods

Balance Predictiveness vs. Parsimony

- **x_i's are the levels of dynamics included/ excluded (capacities)**
- **Y is the response variable (utility)**
- **$Y = f(x_1, x_2, \ldots, x_n)$**
- **$DI = \frac{SSE_{with}/df}{SSE_{without}/df}$**

Qualitative assessment meets Critical Values

Bailey, M. P. and W. G. Kemple. 1994. The Scientific Method of Choosing Model Fidelity, *WSC Proceedings*.

Goals

- Understanding the meaning of *Valid Enough*
- Techniques for uncovering validation shortcomings
  - in the presence of a weak referent
- Expressing validation boundaries
- Being conservative with VV&A resources
- Framework
  - transparent, traceable, repeatable, communicate-able

In Sum

- **Achieve the Goals of Simulation Validation for ABS**
  - **Concentrate on analytical applications**
  - **Test-case-driven & practical**
  - **Institutional acceptability**
  - **Vast collection of potential partners**