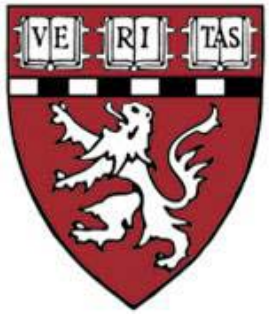


Brandeis University
International Business School

Doing System Dynamics Collaboratively w/Social Scientists

J. Bradley Morrison[1]
Jenny W. Rudolph[2]
John S. Carroll[3]

[1] Brandeis International Business School and MIT Engineering Systems Division
[2] Harvard Medical School and Massachusetts General Hospital
[3] Massachusetts Institute of Technology Sloan School of Management

Diagnostic Problem Solving in an OR Crisis

THE SCENARIO

- **29-yr old female, emergency appendectomy patient**
- **Ventilator bellows straining**
- **Distant breathing sounds**
- **Monitor indicates blood O_2 levels falling dangerously low**

What's the clinical problem?

- **bronchospasm**
- **ventilator machine problem**
- **allergy/anaphylaxis**
- **block in tube**
- **pneumo-thorax**
- **"patient light"**
- **kink in tube**
- **malignant hyperthermia**

Data Sources

- **Videos and transcripts**
- **Post-simulation debriefing summaries**
- **N = 39**

Time (Min)	Words	Actions	Vital Signs
12:00 12:30 13:00	**Dr. Plummer:** Yes. [To Helper] Just give half a cc, like point five. So just 500 mics of epinephrine going in. [The patient has] has got a history of asthma. [To the surgeon] I wouldn't proceed at the moment. **Surgeon:** I know. I'm holding on. **Dr. Plummer:** [To Helper] Would you have a listen to her again? Here is my stethoscope. So the epinephrine is getting there. I've got some CO2, just very poor air entry.... I essentially couldn't hear anything before when I listened. We'll just turn up the isoflurane, try to use that too. **Helper Anes:** Turn it up? **Dr. Plummer:** Just a tiny bit. It's currently working on 2 percent, it's... 100 percent oxygen. **Helper Anes:** Did you give any inhalers? **Surgeon:** Is she getting any better? **Dr. Plummer:** Not at the moment. I've given her four squirts down the tube [addressing Helper's last question]. It's definitely getting CO2 (returning). Initially Dan listened and said it wasn't down the right main bronchus. It's at 22 centimeters [the depth of the endotracheal tube]. I'm happy with that. **Helper Anes:** I can't hear any breath sounds here. **Dr. Plummer:** Yes, she's got very… she is very hard to bag. I'm getting high PIPs [inspiratory pressures]. **Surgeon:** Do you think it's a bronchospasm? **Dr. Plummer:** I think it is bronchospasm at the moment. She's just starting to turn the corner.	Dr. Plummer: hand bagging (manually breathing for the patient) Helper gives Epi 500 mics. At Dr. Plummer's request, Helper listens to the chest. Dr. Plummer still hand bagging. Dr. Plummer checks the depth of the endotracheal tube. Helper listens to the chest. Helper Anesthesiologist turns up anesthetic agent [Isoflurane]	Peak airway pressure gauge reads high HR: 93 BP: 126/81 C02 23 02sat 89 HR 169; BP 113/90; CO2 24 O2 sat 88 (Post epinephrine)

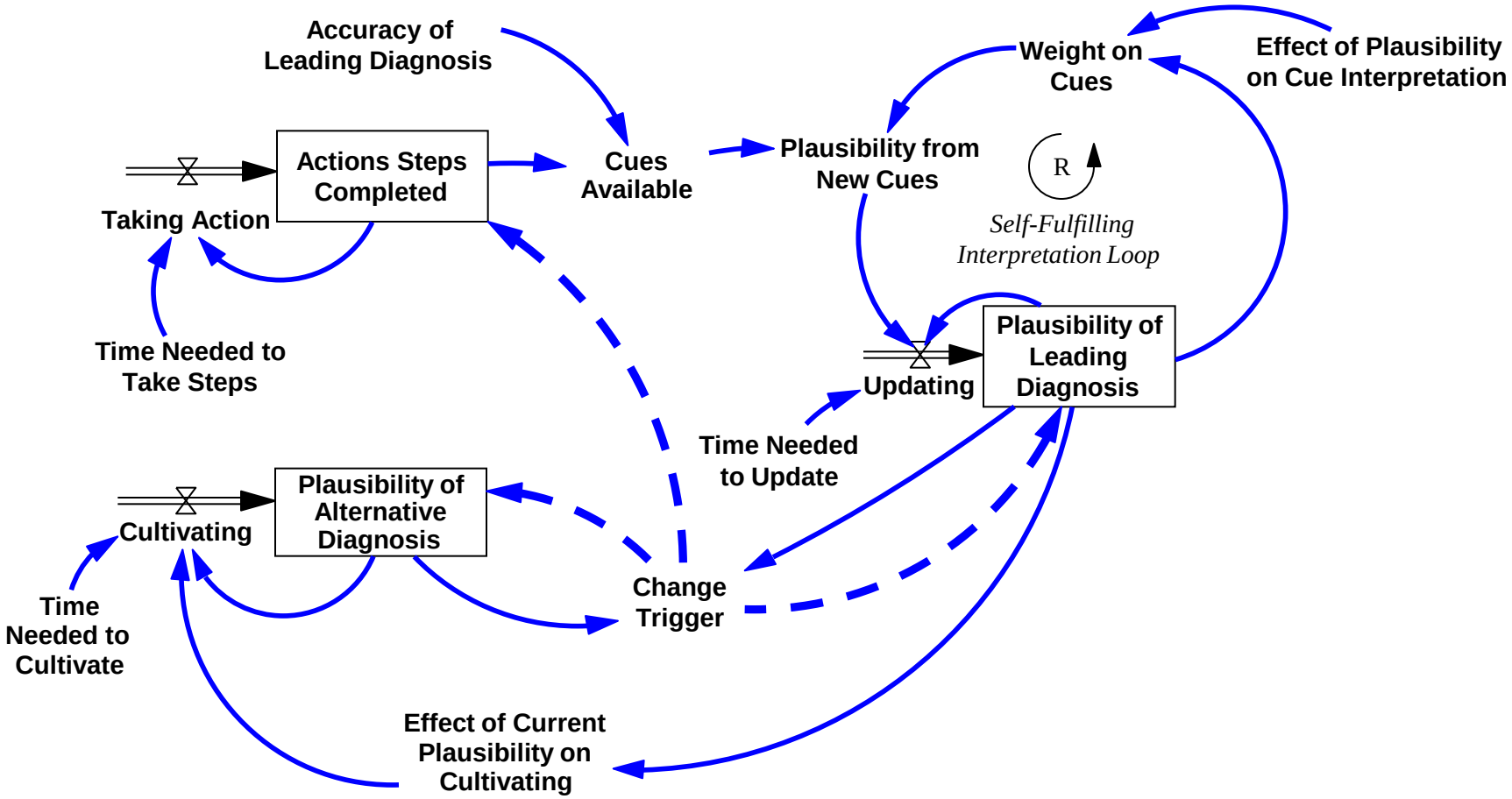
1. Bronchospasm						O	❶	O			❶		O
2. < Relaxation							❶	O					O
3. Tube placement							❶				O	O	
4. < Anesthesia							❶						O
5. Ventilator prob.									O	O	❶		
6. < Blood volume									O		O		
7. Collapsed lung											O		
8**. Blocked tube**												❶	O
O^2 Saturation	97	97	99	99	99	99	99	95	?	92	93	92	91
Time	2	4	6	8	10	12	14	16	18	20	22	24	26

Problem Solving Modes in Source Data

	FAILURE MODES				
Variable	**Stalled**	**Fixated**	**Vagabonds**	**Adaptive**	Test of difference
N	**2 (5%)**	**11 (28%)**	**17 (44%)**	**9 (23%)**	–
Subjects who resolved the airway problem	**0**	**0**	**0**	**7**	ChiSq(3) = 28.4***
Different Treatment Steps for a Diagnosis	**1.0 (0.0)**	**2.0 (1.1)**	**1.5 (0.5)**	**3.6 (0.7)**	*F*(3,35) = 17.0***
Considerations of Favorite Diagnosis	**3.0 (0.0)**	**10.0 (5.7)**	**5.4 (2.3)**	**5.9 (2.2)**	*F*(3,35) = 5.0**
Number of Different Diagnoses Considered	**1.5 (0.7)**	**3.8 (1.7)**	**6.1 (1.3)**	**5.0 (1.4)**	*F*(3,35) = 9.1***

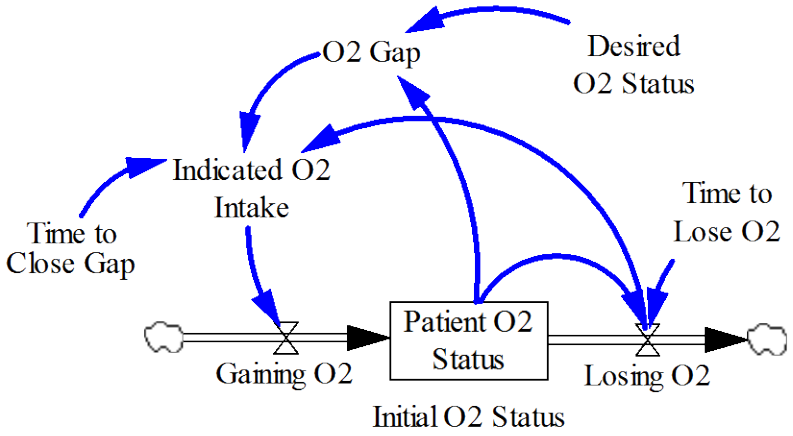
Note -- means are given with standard deviation in parentheses. ** p < .01; *** $p < .001$

Action-Oriented Problem Solving

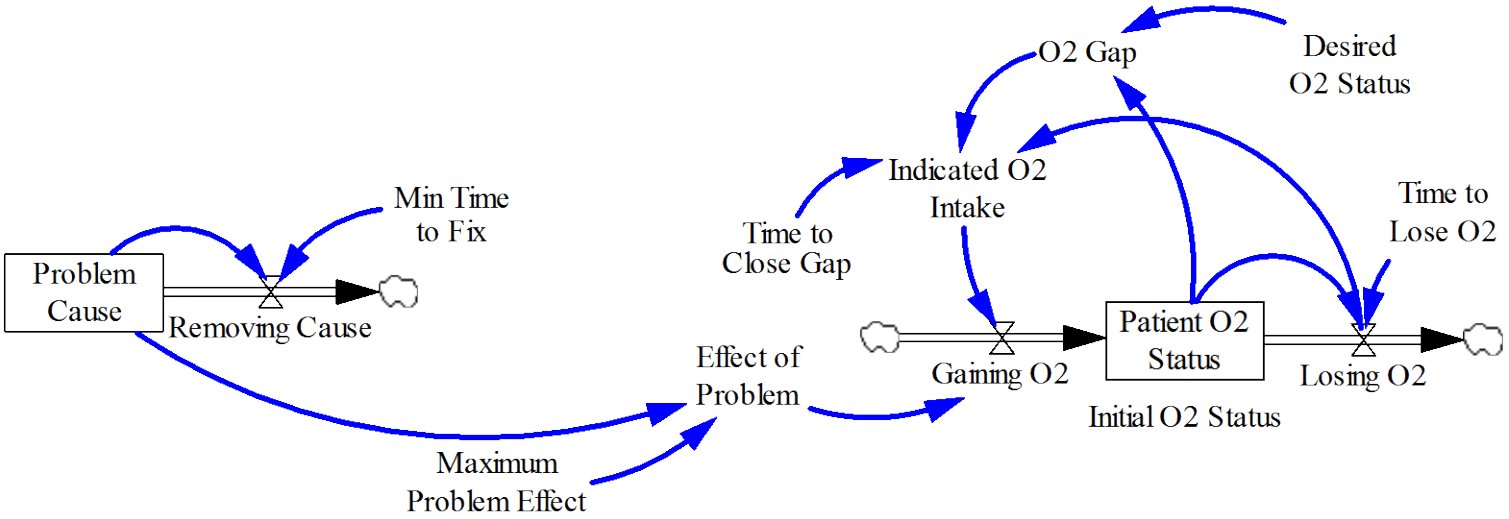


The Collaboration Begins

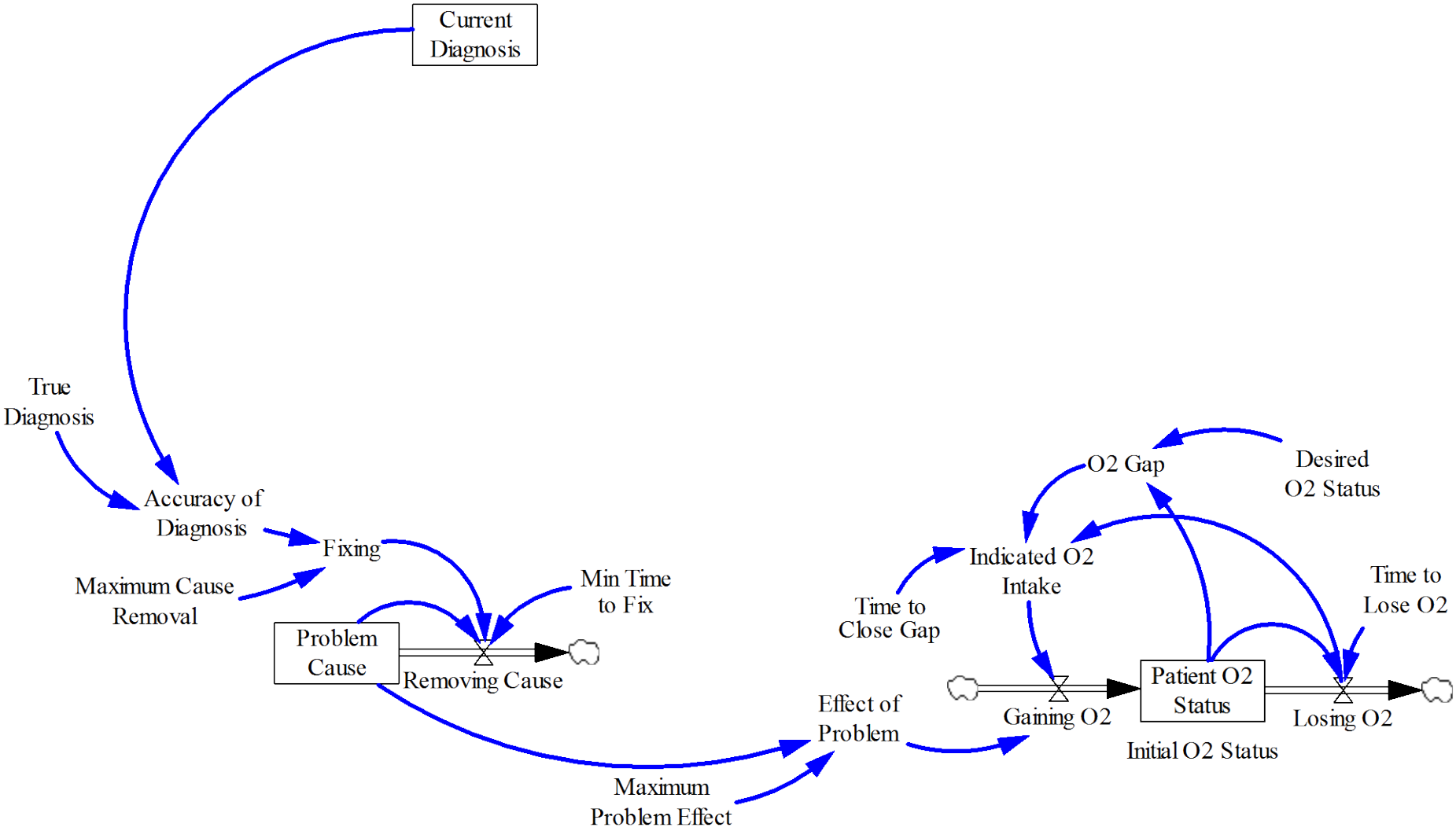
An Early Model of the Doctors' Problem



An Early Model of the Doctors' Problem

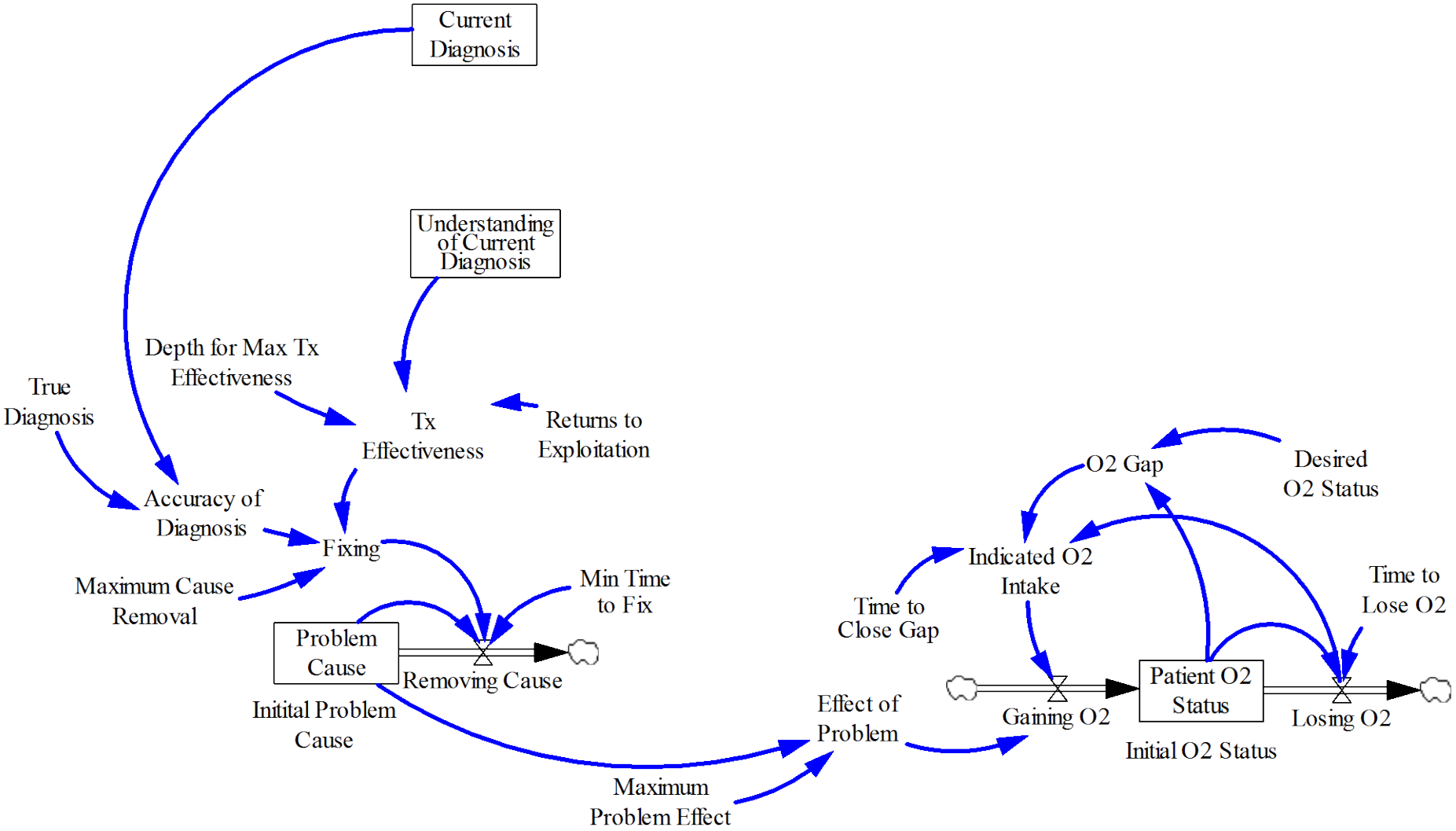


An Early Model of the Doctors' Problem



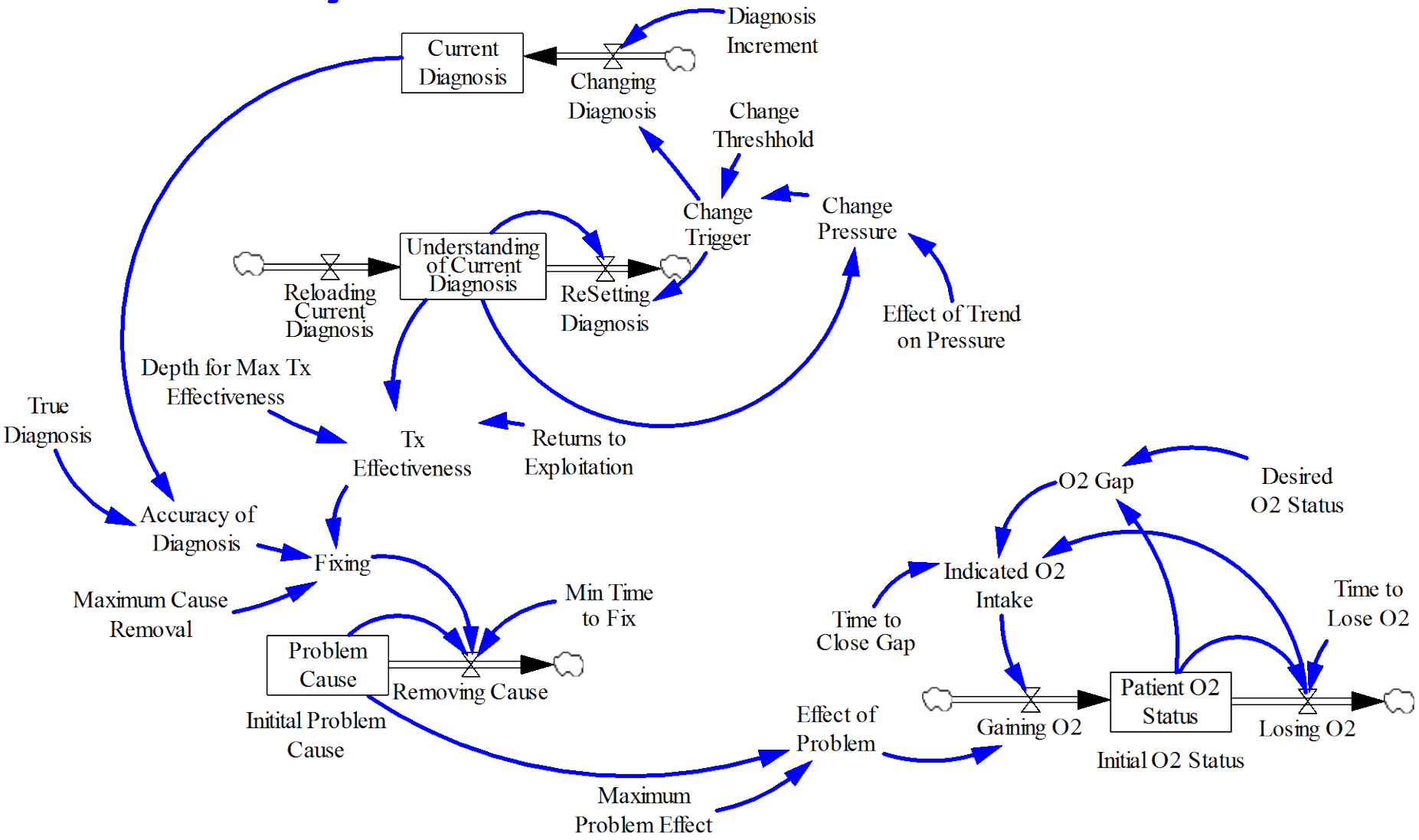
MedDiag3 1/8/07

An Early Model of the Doctors' Problem



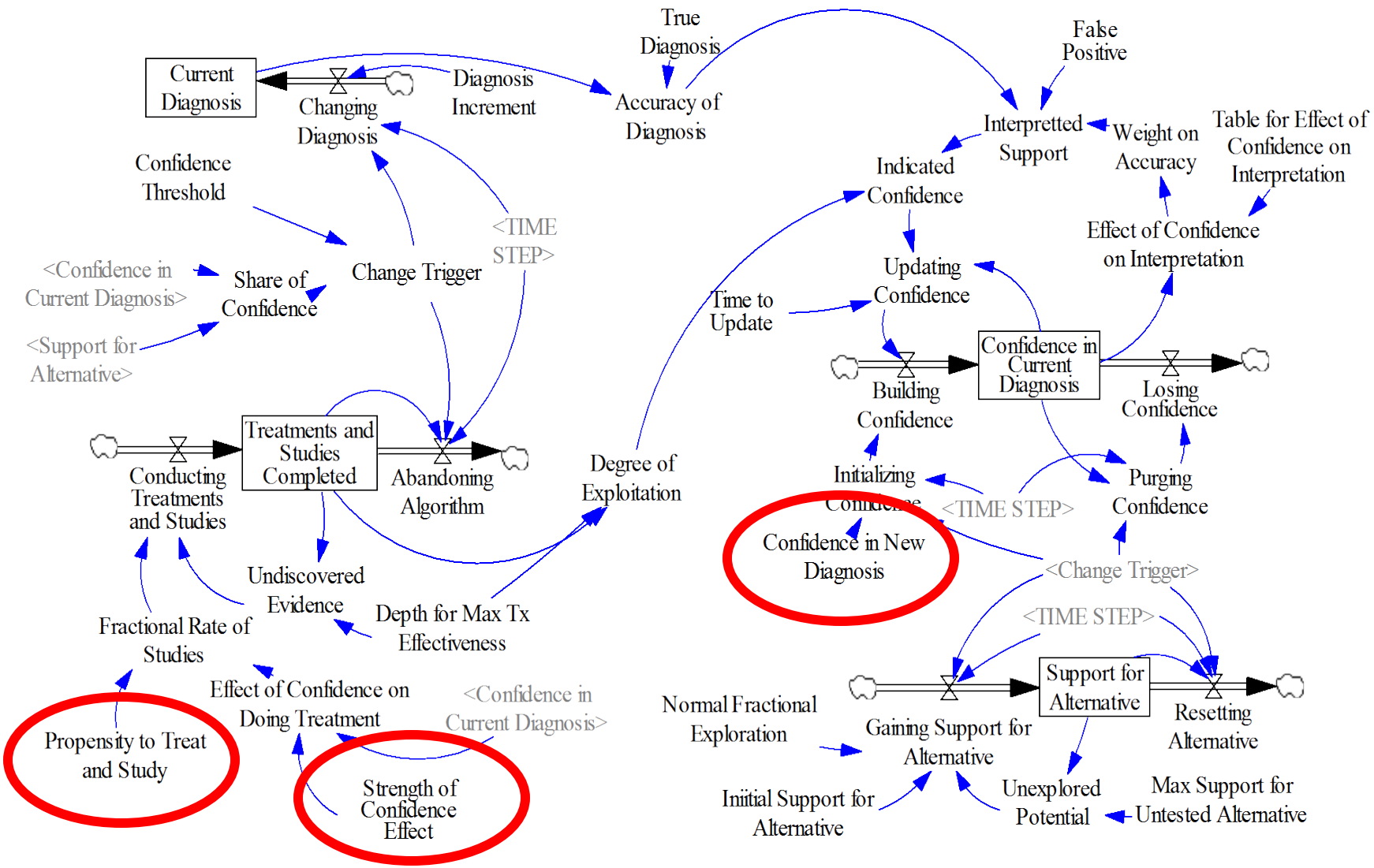
MedDiag3 1/8/07

An Early Model of the Doctors' Problem



MedDiag3 1/8/07

A Few Weeks Later



From Confidence, Error, and Ingenuity, JWR and JBM, Jan 2007

Replicating Three Behavior Modes

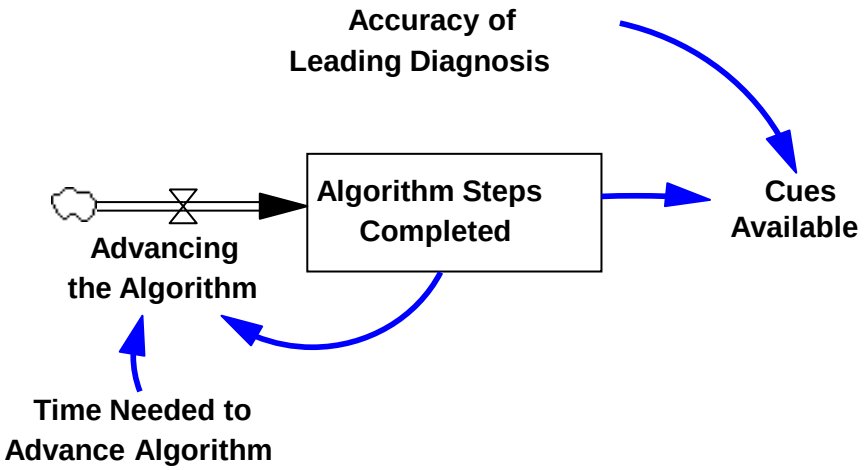
… by changing three parameters

	Confidence in New Diagnosis	Propensity to Treat and Study	Strength of Confidence Effect	Rationale
Units	Fraction	1/minute	Dimensionless	
Fixating	0.75	1	1	Overconfident in proposed diagnosis
Diagnostic Vagabonding	0.5	0.3	3	Cautious to take action
Adapting	0.5	1	1	Willing to question and to act

The Collaboration Continues

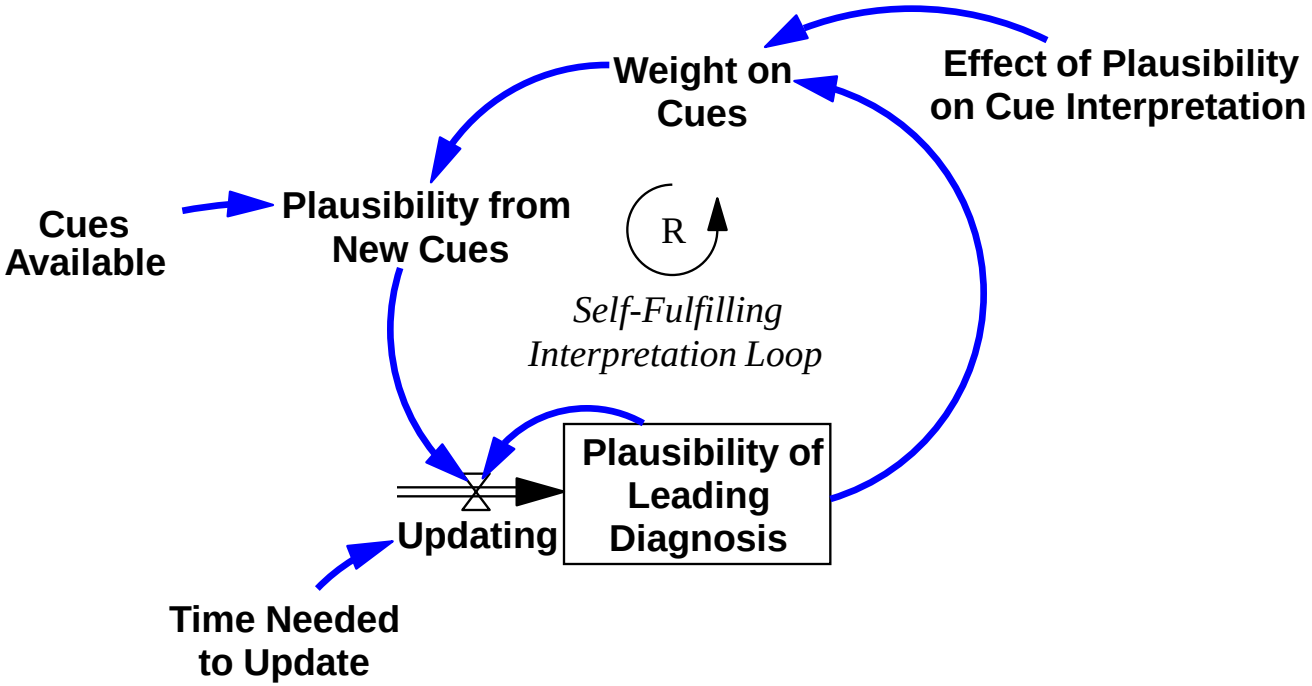
ACTING

- **Acting:** **Following the steps of a diagnostic algorithm, making cues available.**

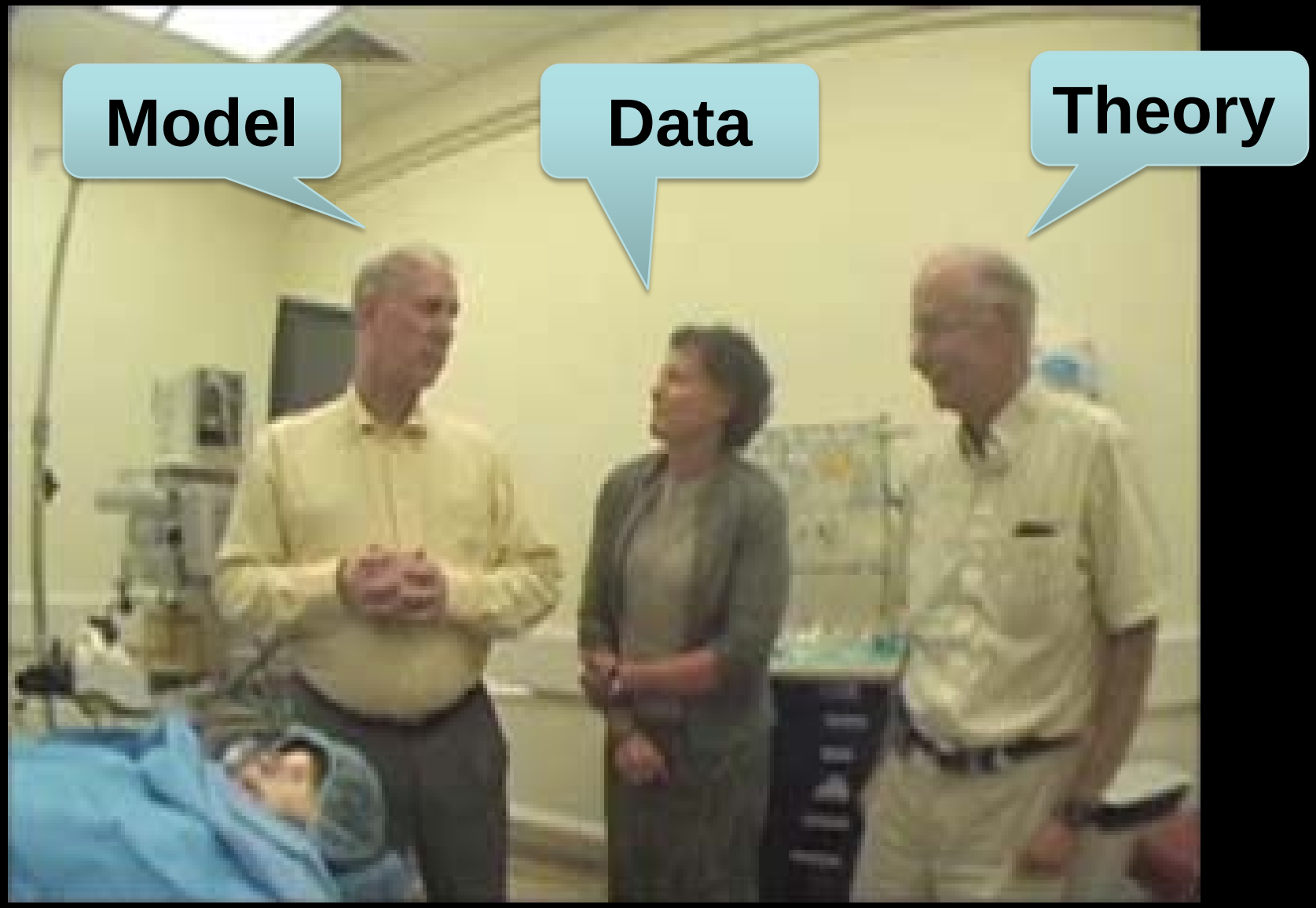


INTERPRETING AND UPDATING

Interpreting and Updating: Making sense of new information to update beliefs.

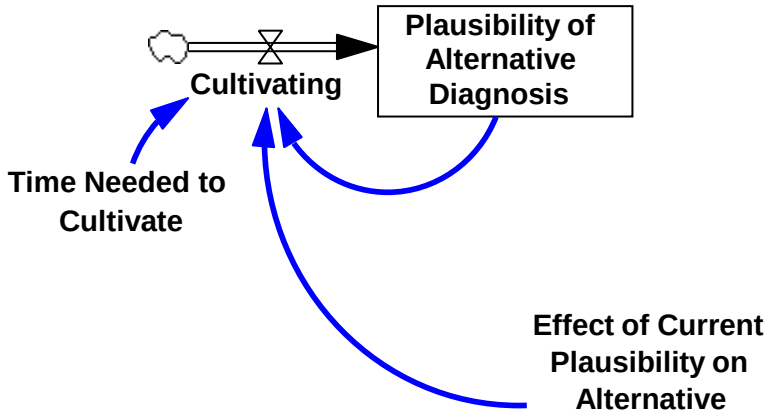


Forms a reinforcing loop, often implicated in studies of fixation

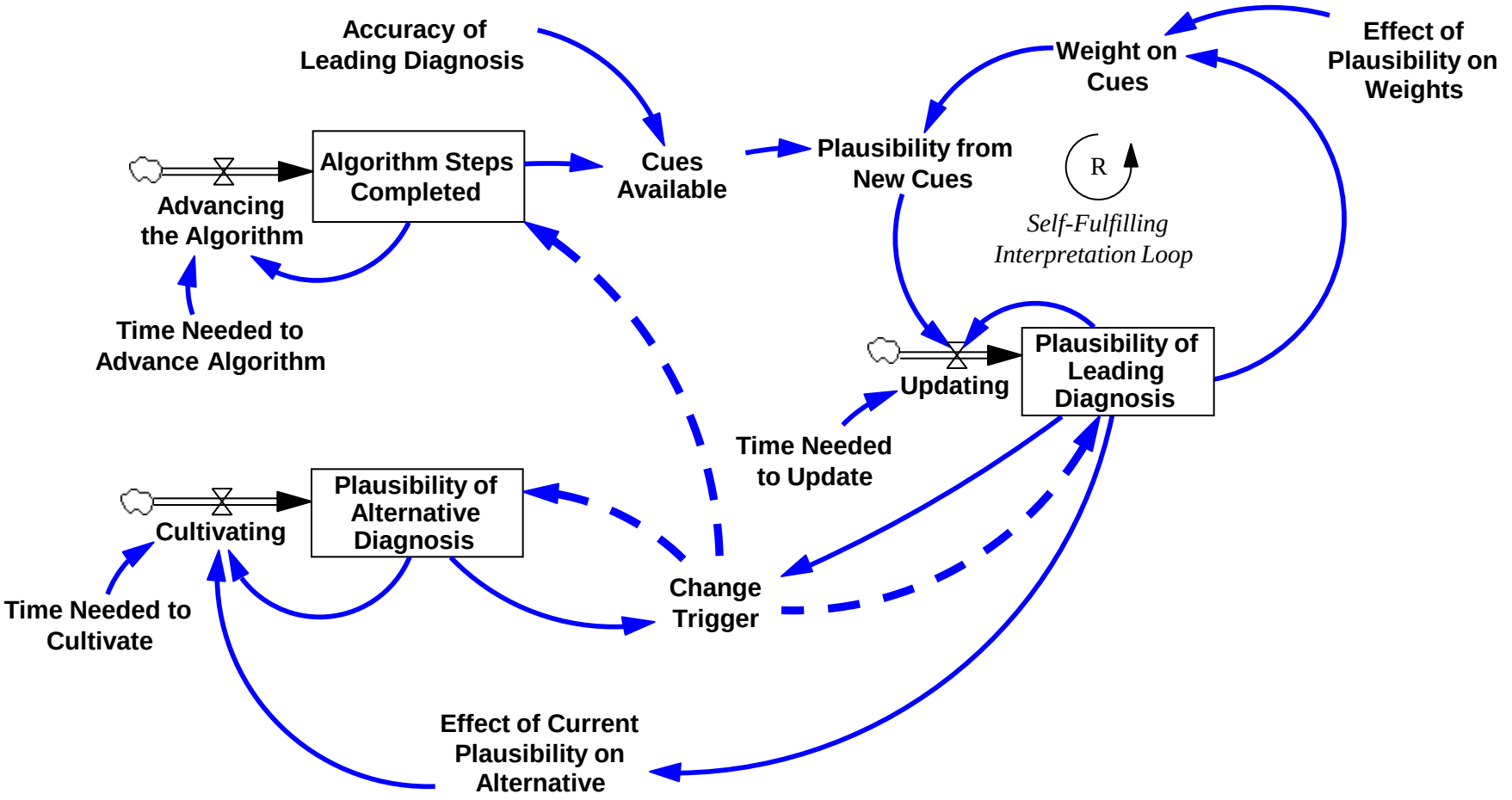

Model
Data
Theory

CULTIVATING ALTERNATIVES

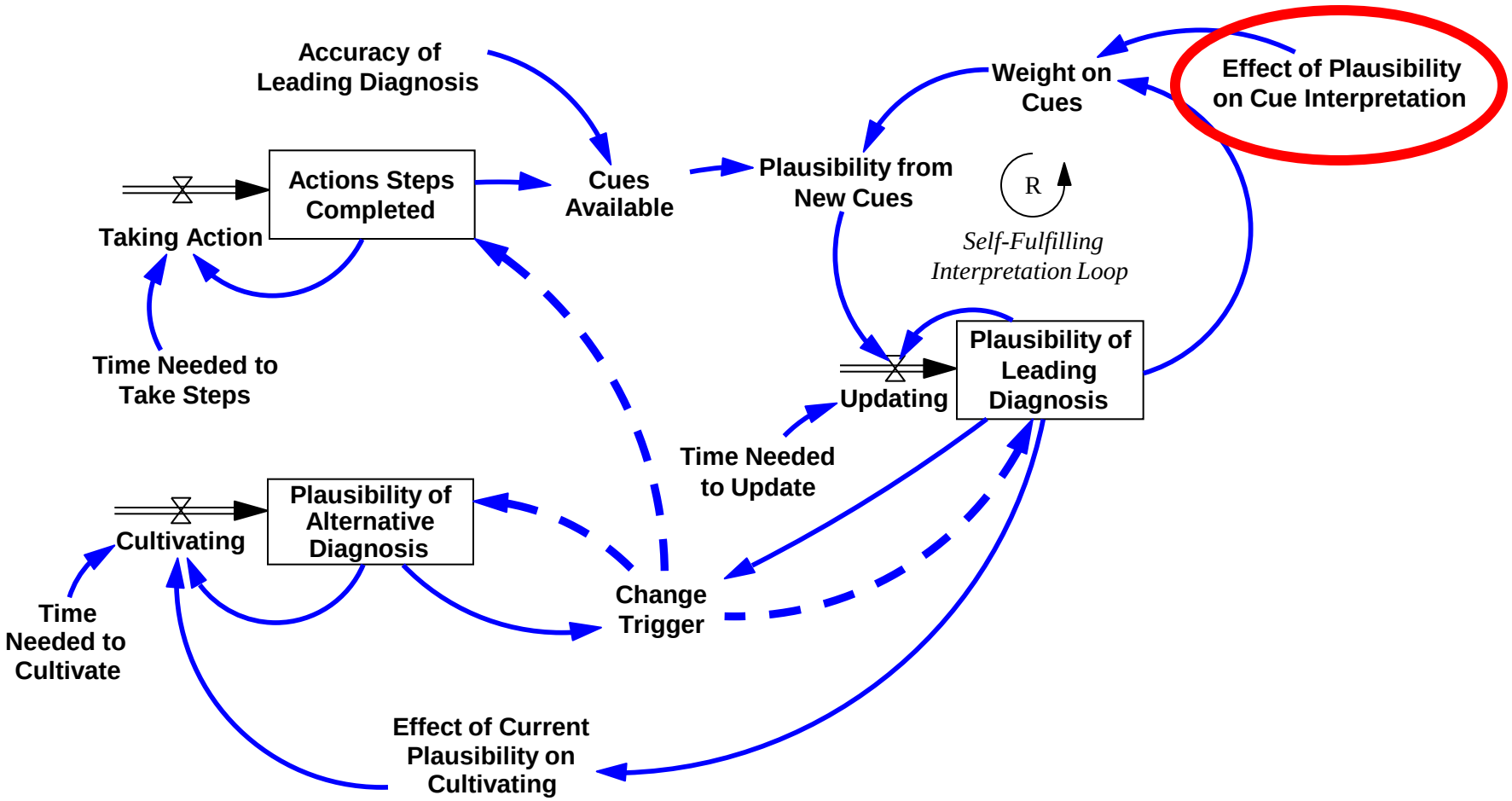
Cultivating Alternatives: **Searching for and contemplating the merits of alternatives.**



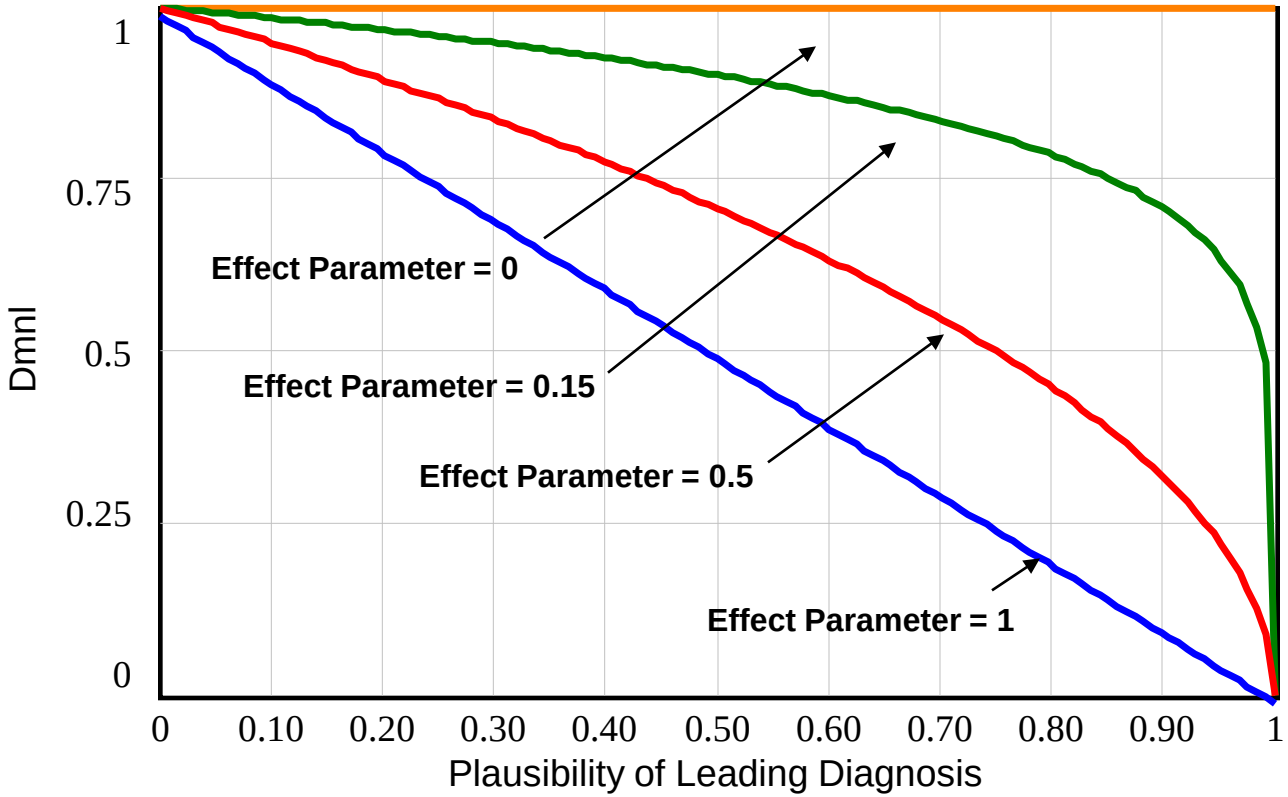
Action-Oriented Problem Solving



Action-Oriented Problem Solving

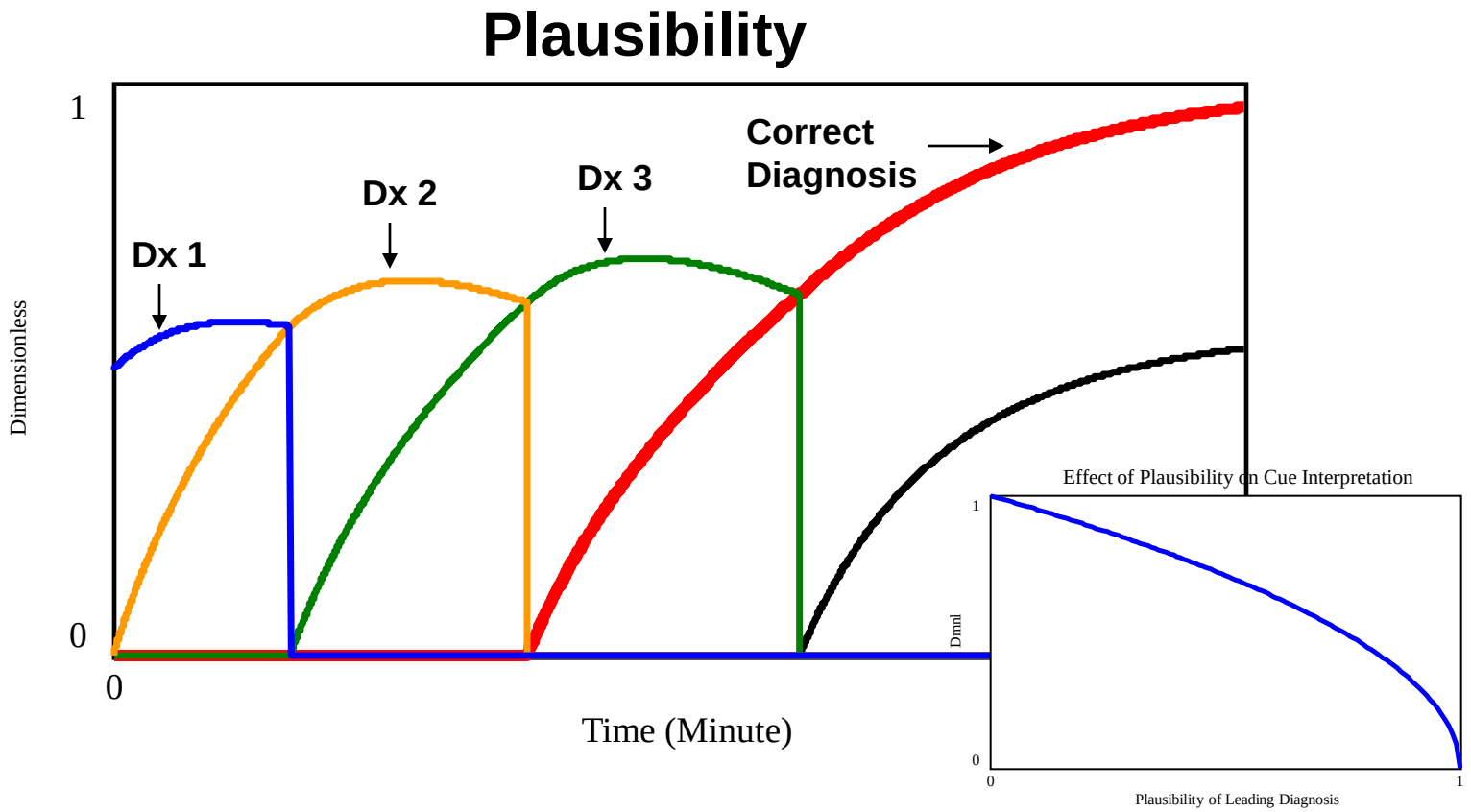


Effect of Plausibility on Cue Interpretation

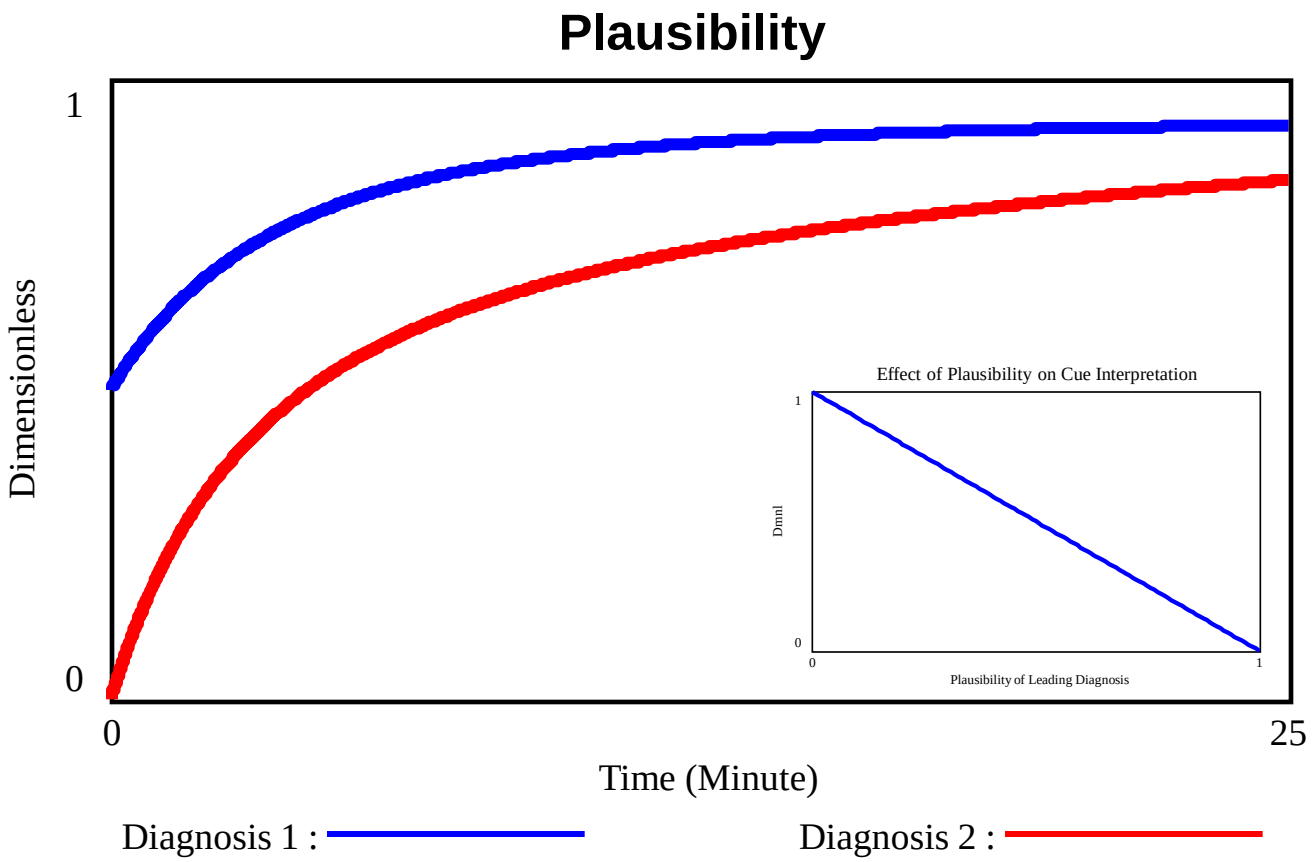


Weight on Cues = (1 – Plaus of Leading Dx) Effect of Plausibility on Cue Interpretation

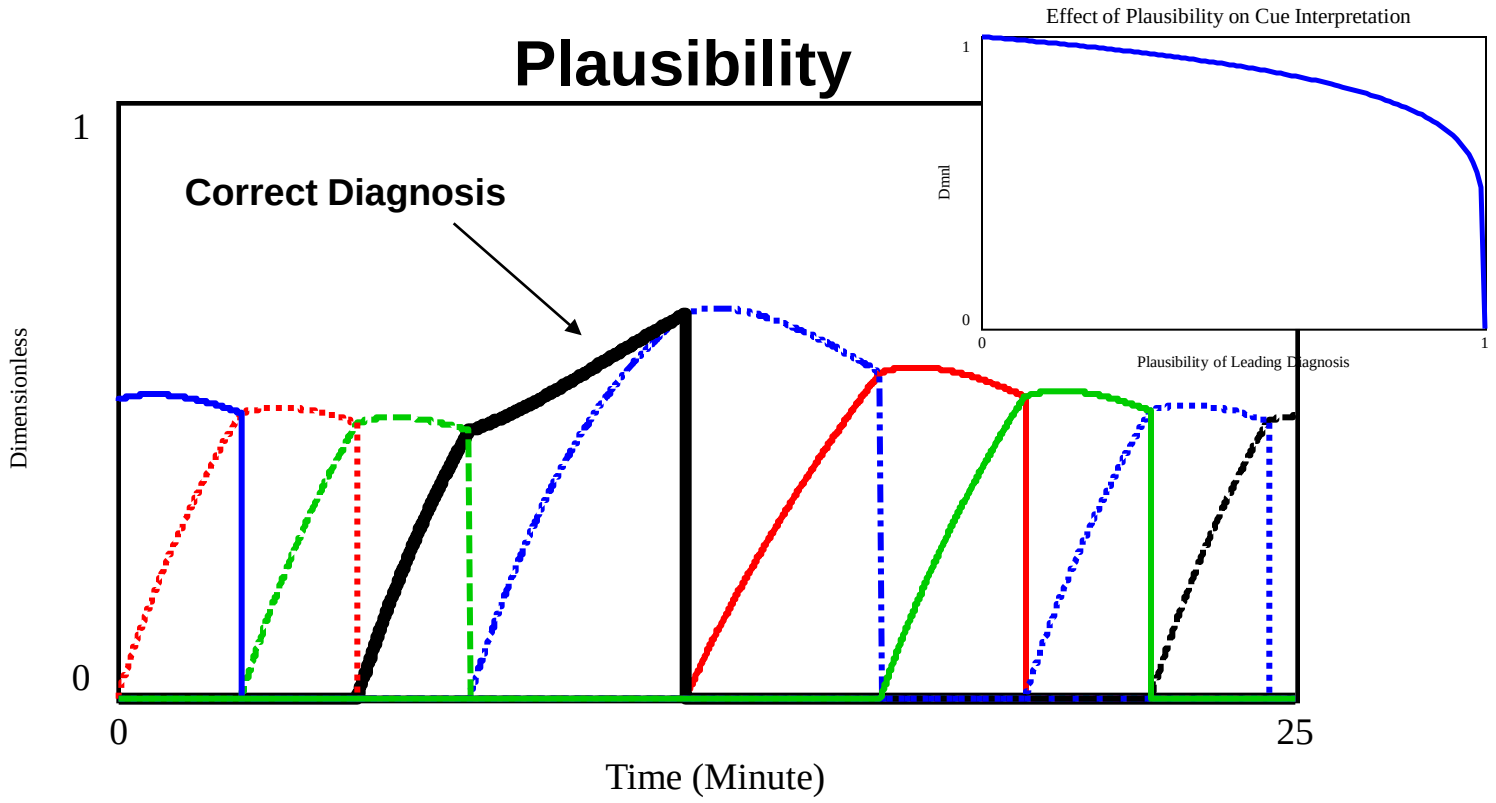
Adaptive Problem Solving: Finding and Accepting the Correct Diagnosis



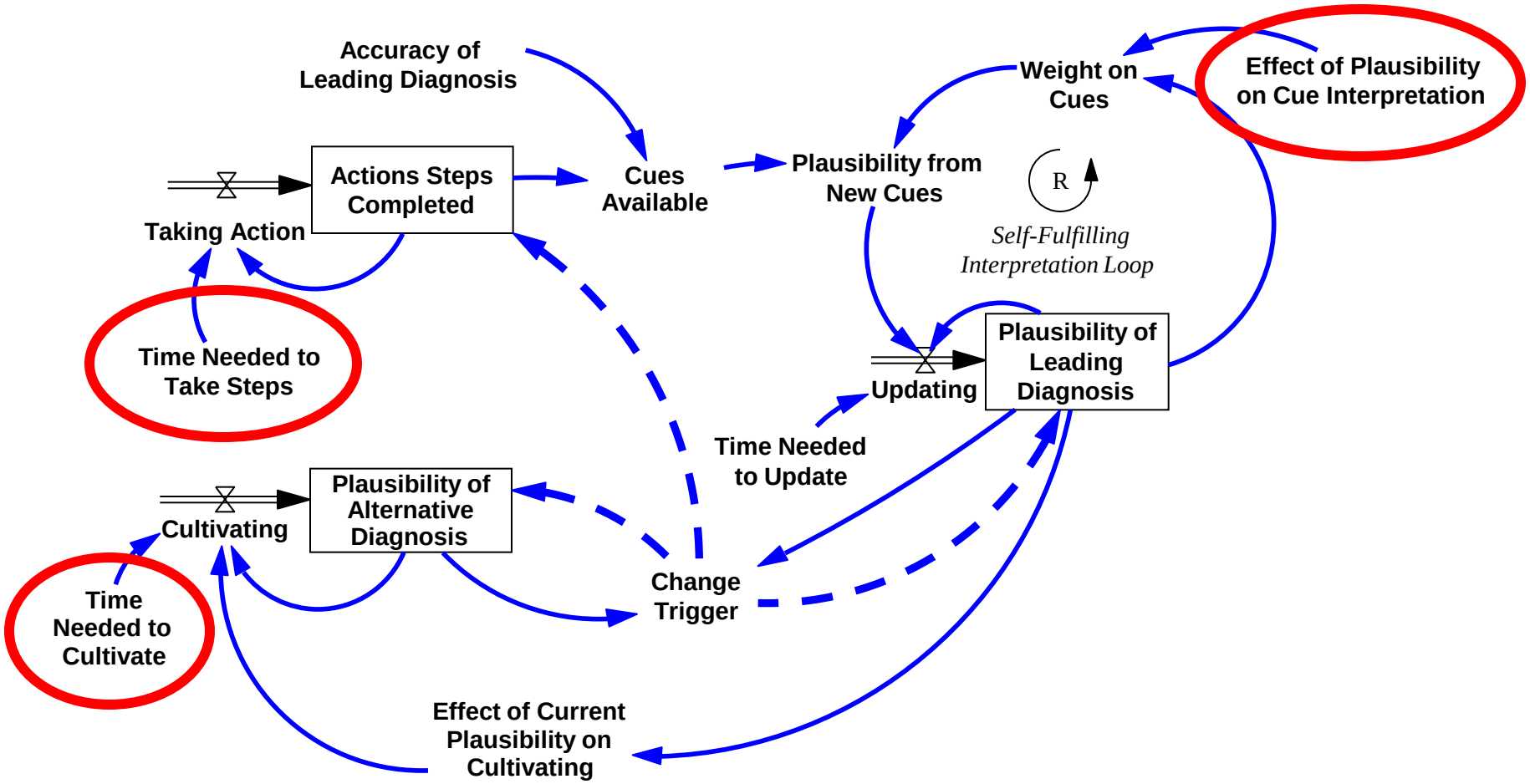
Fixation: Strong Effect of Plausibility



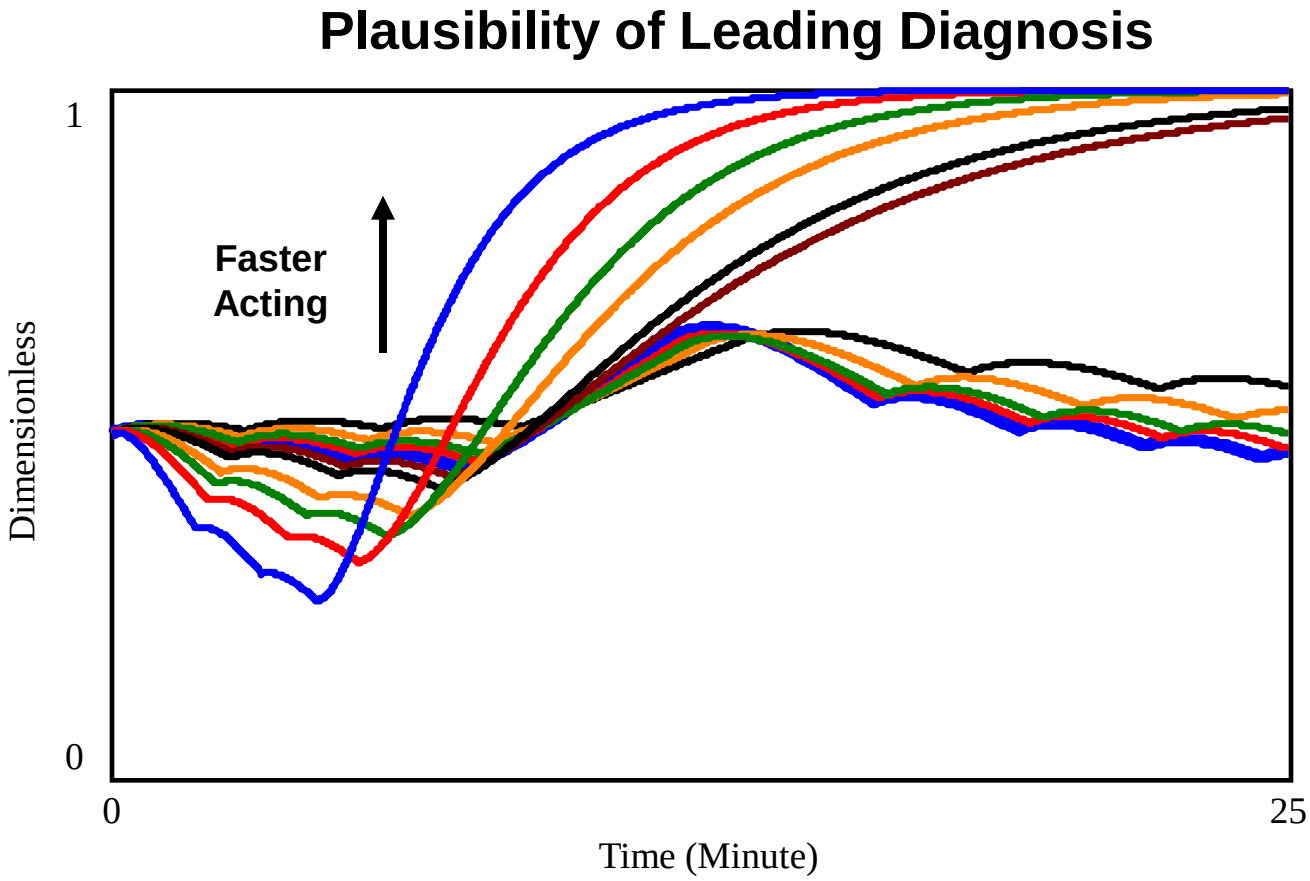
Vagabonding: Weak Effect of Plausibility



Action-Oriented Problem Solving

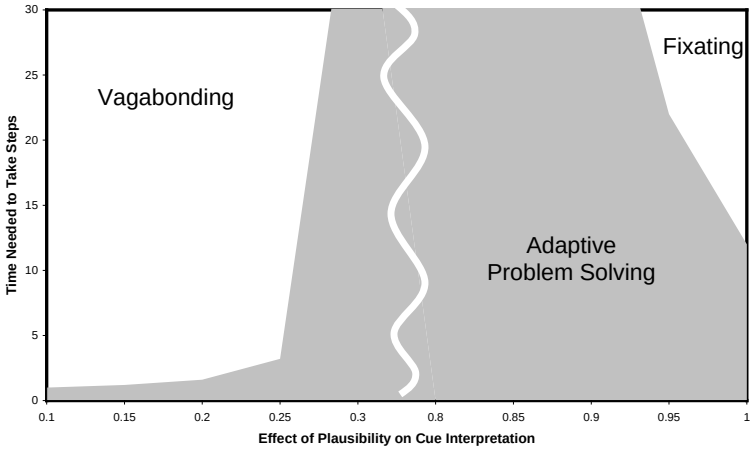


Sensitivity to the Pace of Acting

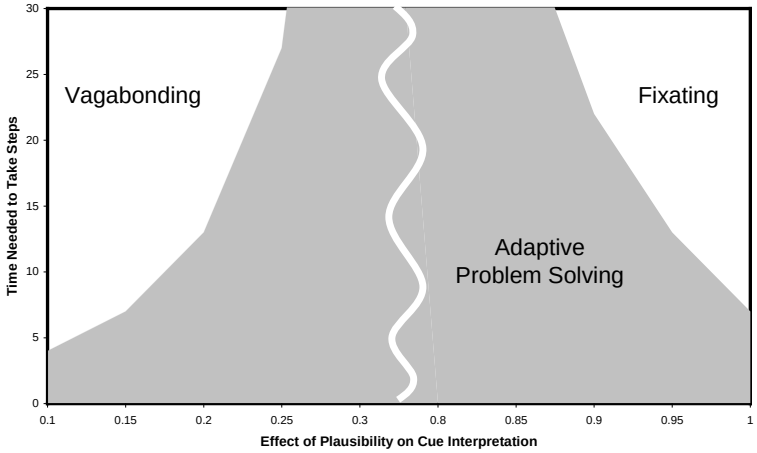


Threshold Values of the Pace of Taking Action

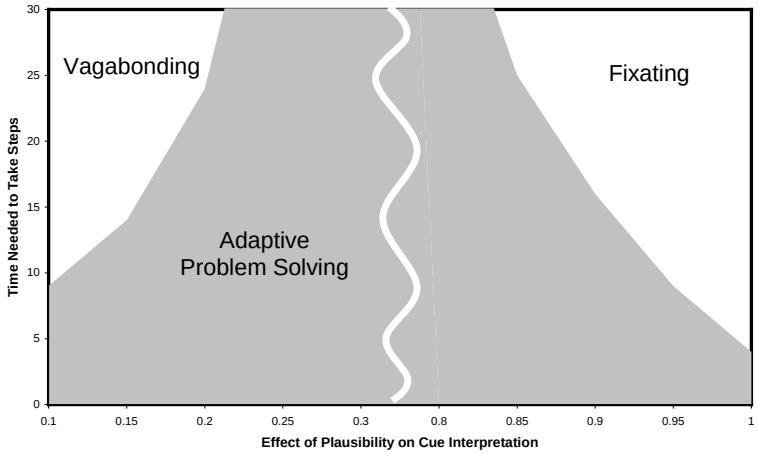
Time Needed to Cultivate = 2



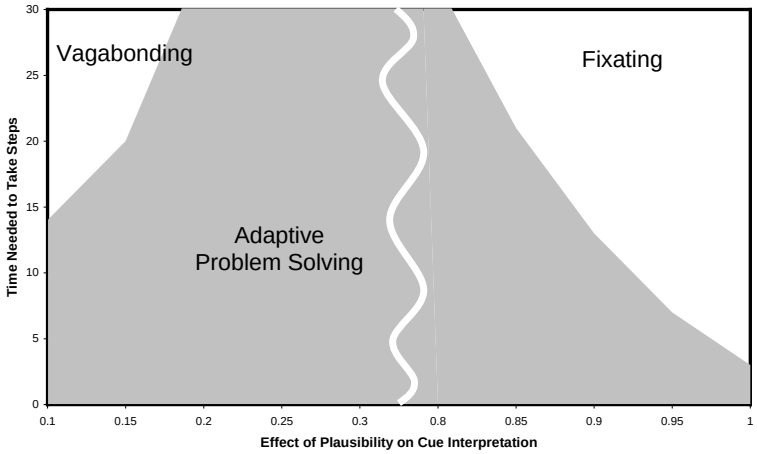
Time Needed to Cultivate = 4



Time Needed to Cultivate = 6



Time Needed to Cultivate = 8



Action-oriented problem solving: Boundary conditions

1. **Action-based inquiry** – action is required to generate new cues; cues are used to update explanations and action strategies;

2. **Temporal dynamism** -- the world keeps changing as explanations or strategies for action are devised and revised;

3. **Action-endogeneity** --actions change the problem solving environment.

Summary

- **Dynamic problem solving comprises acting, interpreting, and cultivating alternatives.**
- **The outputs of sensemaking and choice are inputs to each other.**
- **Self-fulfilling interpretation can be beneficial.**
  - **"OVER-Confidence" can lead to failure.**
  - **"UNDER-Confidence" can also lead to failure.**
- **The pace of acting, the pace of cultivating, and the strength of the interpretation effect interact in a compensatory manner.**
  - **Each component process offers a possible remedy to "out-of-balance" problem solving.**

Small models are beautiful!

But, they are not easy.

1. **Grounded theory and data**
2. **Collaboration**
3. **Communication**

Grounded Theory and Data

Start with real, thick descriptive data

Iterate among model, data, and theory

Ask questions of the data

Use the model as a boundary object

Collaboration

- **Choose awesome collaborators!**
  - **Mutual respect**
  - **Moderate boundaries**
  - **Skillful at discourse**
- **Choose a problem you all care about – and define it dynamically**
- **Allow for plenty of iterations to develop shared understanding**
- **Keep the model, the data, and the theory in the process**
- **Learn to collaborate with reviewers**

Collaboration

- **Balance the rigor of conceptualizing and formulating versus playfulness and curiosity**
- **Love your model enough to squeeze out the wisdom, but not so much that you can't let go**

WE NEED TO GET GOOD AT THIS:

- **Develop skills to co-create with others**
- **Don't impose a modeler's view of structure**
- **Humbly admit you're not the modeler**
- **Access your ignorance**

Communication

- **Create models of the appropriate size**
- **Connect with theory and practice for your constituents**
- **Build intuition and understanding**
    - **Shift the focus away from the model and towards the lessons**
- **Choose your audience wisely**

WE NEED TO GET GOOD AT ALL THIS!

Adapted from Repenning (2003) Selling system dynamics to (other) social scientists, SDR, 19:4

Thank You !!