

Clinical Decision-Making in Sepsis: From Big Data to Behavioral Economics

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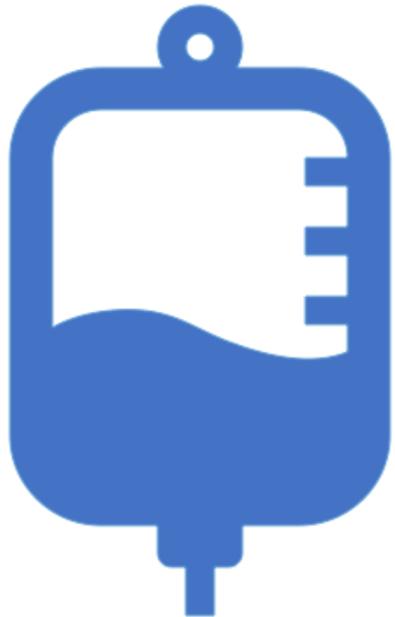
Declaration of Interests

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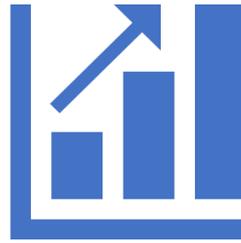
Funding sources had no role in study design; collection, analysis, and interpretation of data

Fluid Resuscitation in Sepsis



Big Data

Patterns and
Outcomes



Hospital Practice



Mental Models



Behavioral Economics

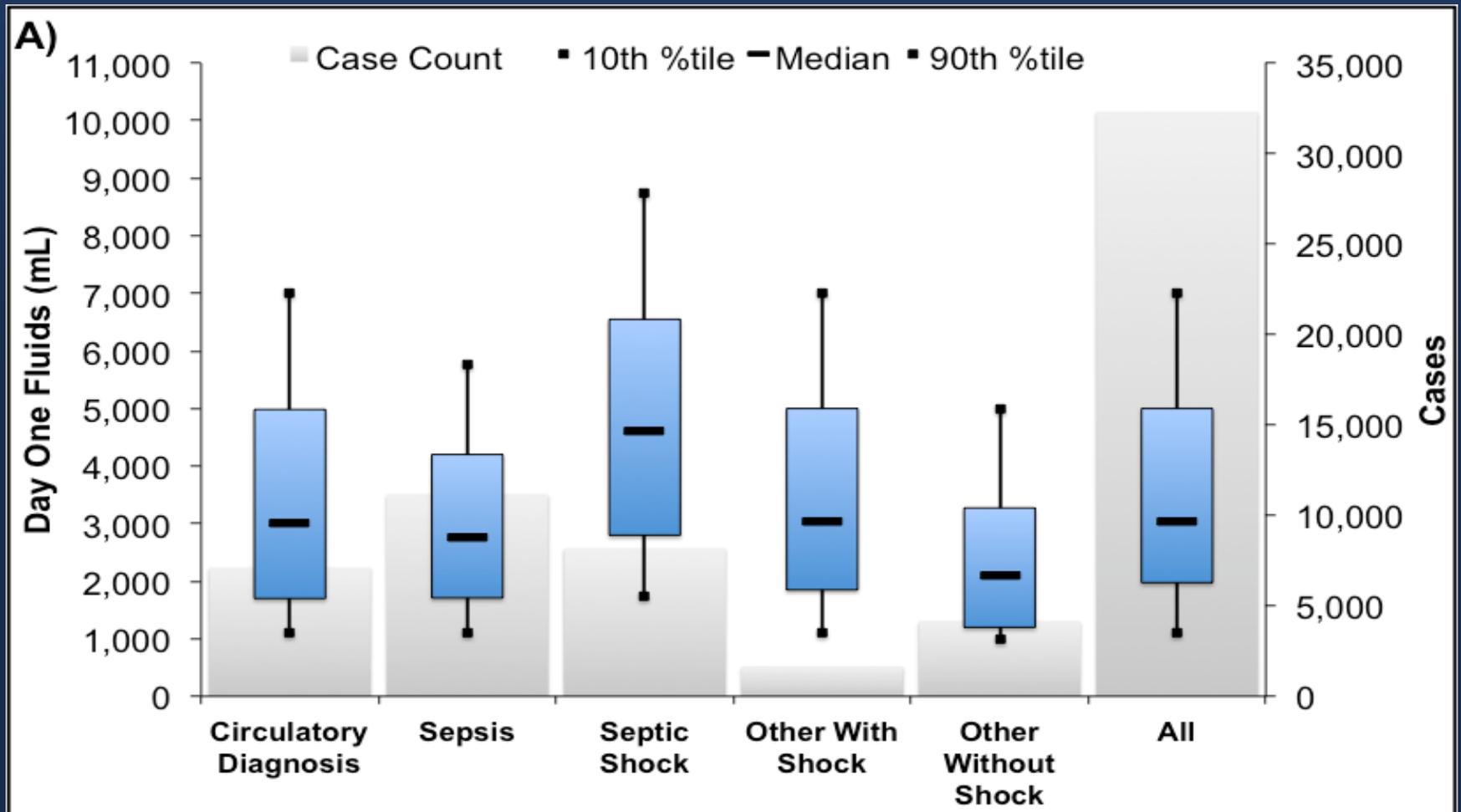
Choice
Architecture



Risk Preferences



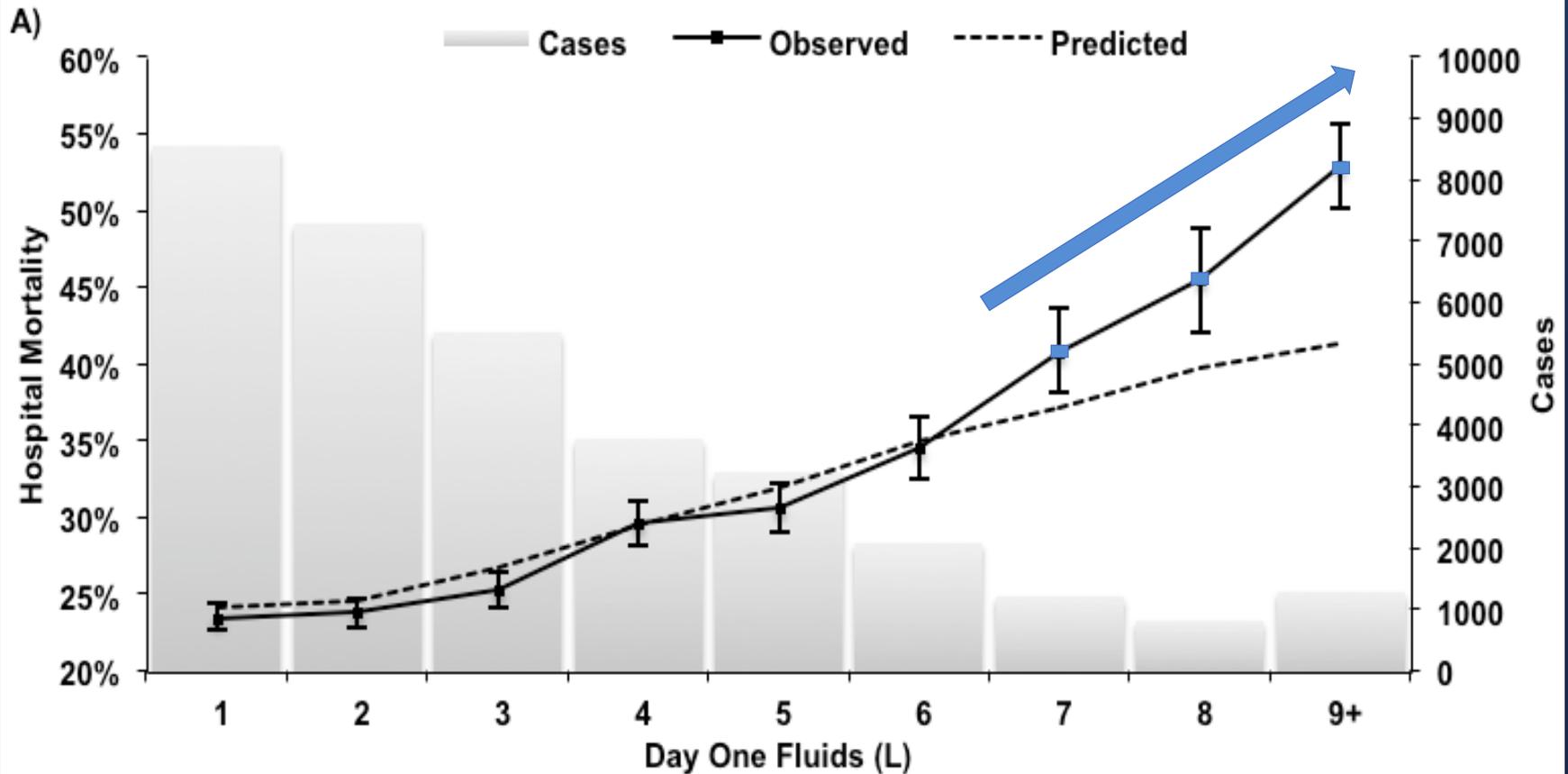
Variable Day One Fluid Prescribing Practices



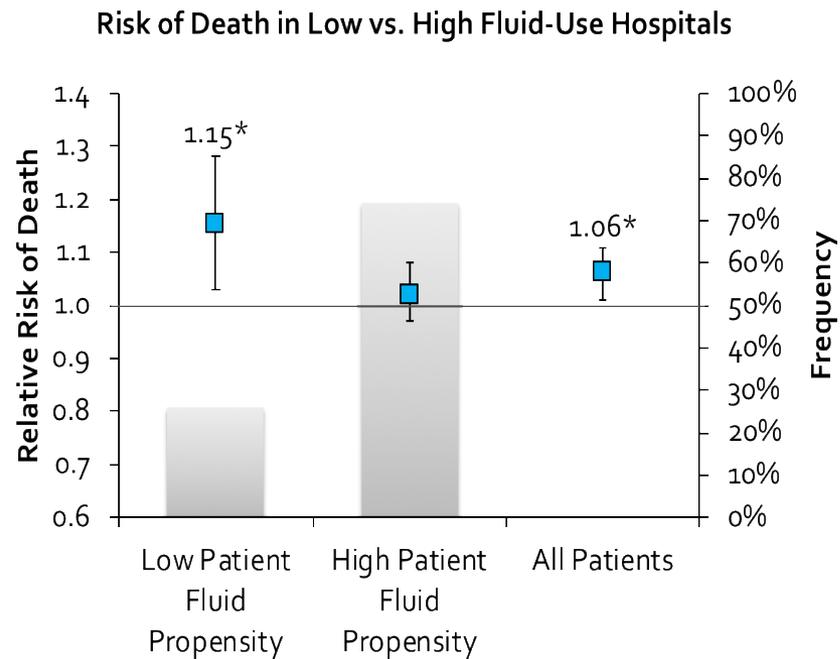
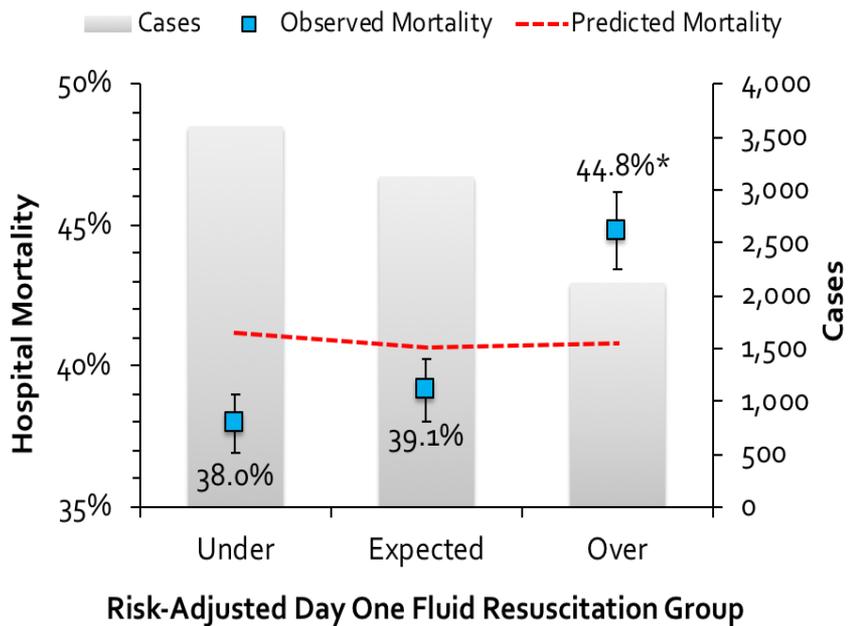
Median day 1 fluids for all = 3,050mL, IQR 1,975-5,000mL

Observed vs. Predicted Hospital Mortality

Figure 3. The effect of day one fluid resuscitation volume on hospital mortality



The difference between observed and predicted mortality is significant when 95 percent CI bars do not cross the line for predicted mortality.



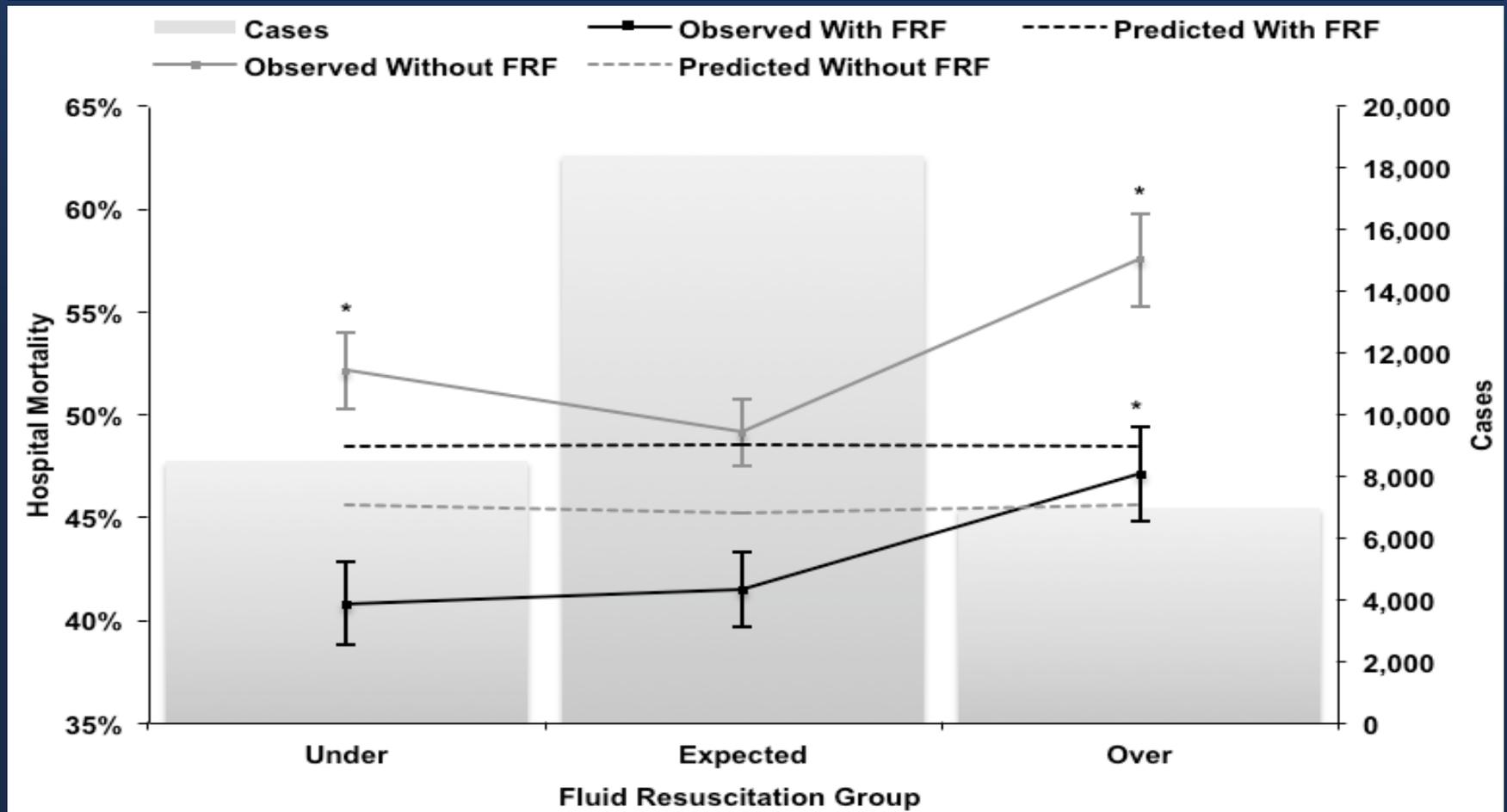
Mortality increased with greater than expected day one fluid volumes, but..

Risk of death was increased in low fluid-use hospitals

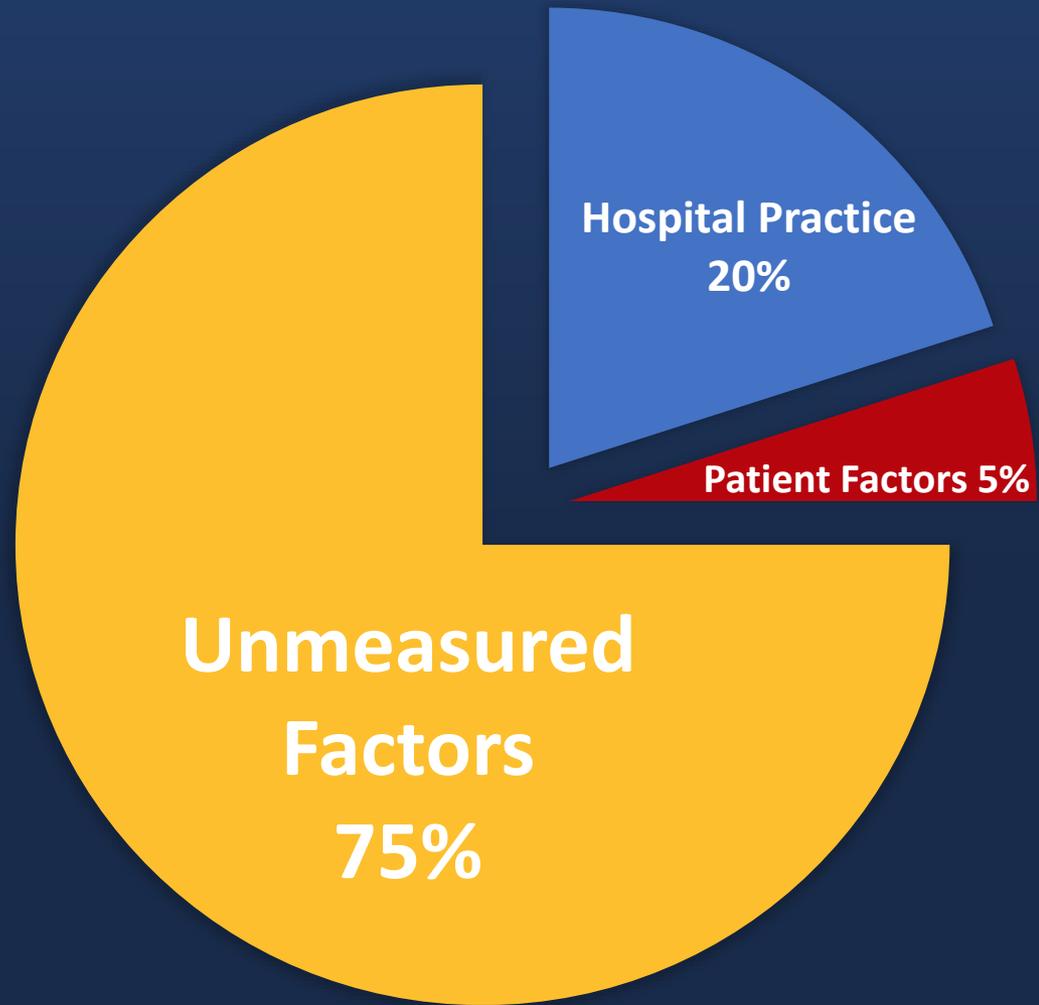
Covariates: Age, Gender, Admission diagnoses (ICD-9-CM codes present in at least 3% of patients)

Observed vs. Predicted Hospital Mortality

Figure 4. The effect of day one fluid volume under- or over-resuscitation on hospital mortality



Predicted Day One Fluid Error Partition





Clinical Decision-Making in Sepsis: Integrating the Decision Sciences

Neoclassical vs. Behavioral Economics

- Neoclassical Economics:
 - Decision-makers are **rational** and have sufficient information to make decisions
 - Decisions are guided by *utility function*
 - If mistakes are made, they are **random** ones
- Behavioral Economics
 - Incomplete information abounds
 - Not all decisions are rational
 - Deviations from rational choice are **systemic and predictable (cognitive biases)**

Other Key Terms

- Heuristics
 - Mental shortcuts or rules of thumb that ease the cognitive load of making a decision
- Choice Architecture
 - The practice of influencing choice by changing the manner in which options are presented and the environmental conditions under which choices are made

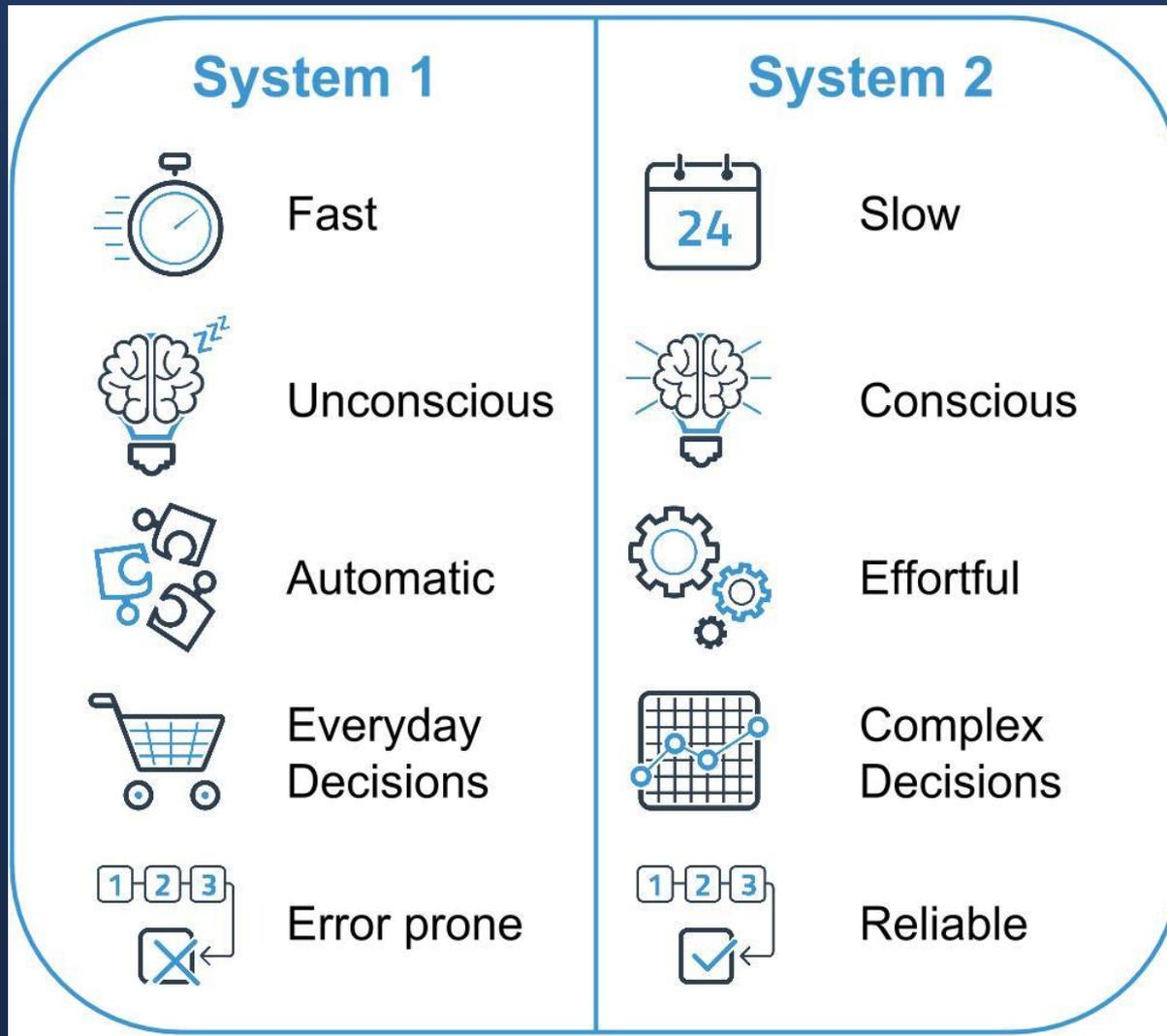


Significance to Clinical Practice

- Cognitive biases in clinician decision-making -> **low-value care**
 - Unintended retention of foreign objects (e.g., **search satisficing**)
 - Wrong site surgeries (e.g., **confirmation bias**)
 - Patient falls (e.g., **availability and ascertainment bias**)
 - Diagnostic errors that may result in treatment delays (e.g., **anchoring, framing, and premature closure**)

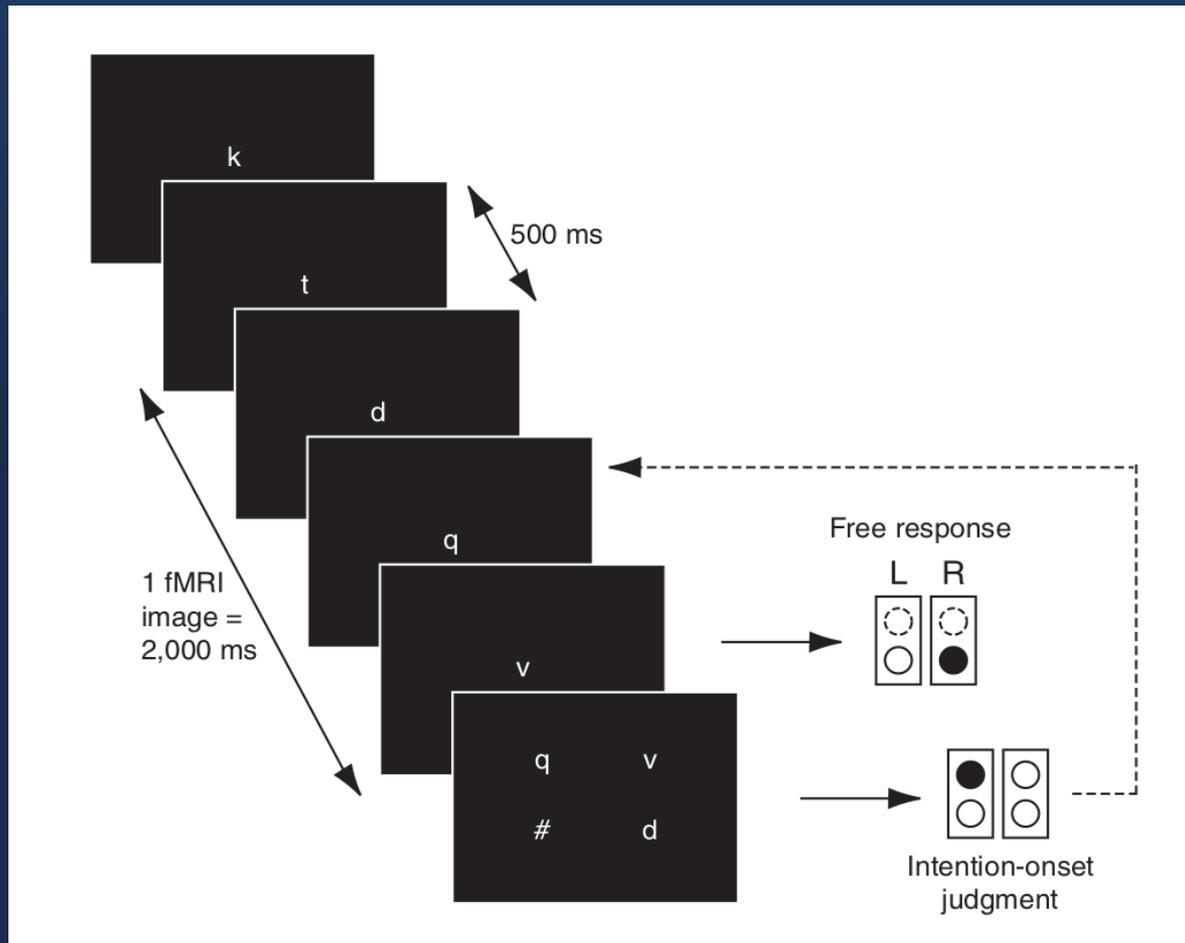
Dual Process Theory

INTUITIVE
THINKING



ANALYTICAL
THINKING

Unconscious Decision-Making

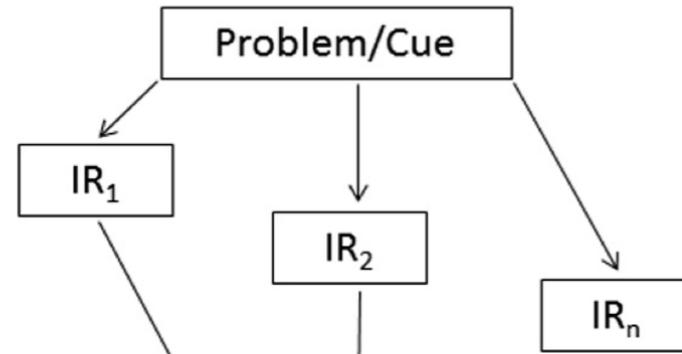


- Predictive neural information (frontopolar cortex) preceded the conscious motor decision by up to **10 seconds**

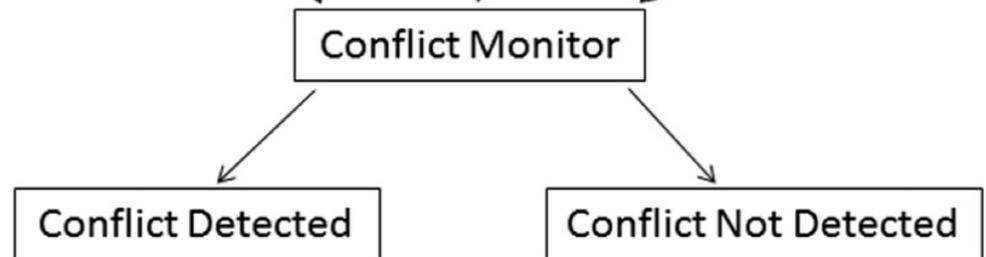
“This delay presumably reflects the operation of a network of high-level control areas that begin to prepare an upcoming decision long before it enters awareness.”

INTUITIVE
THINKING

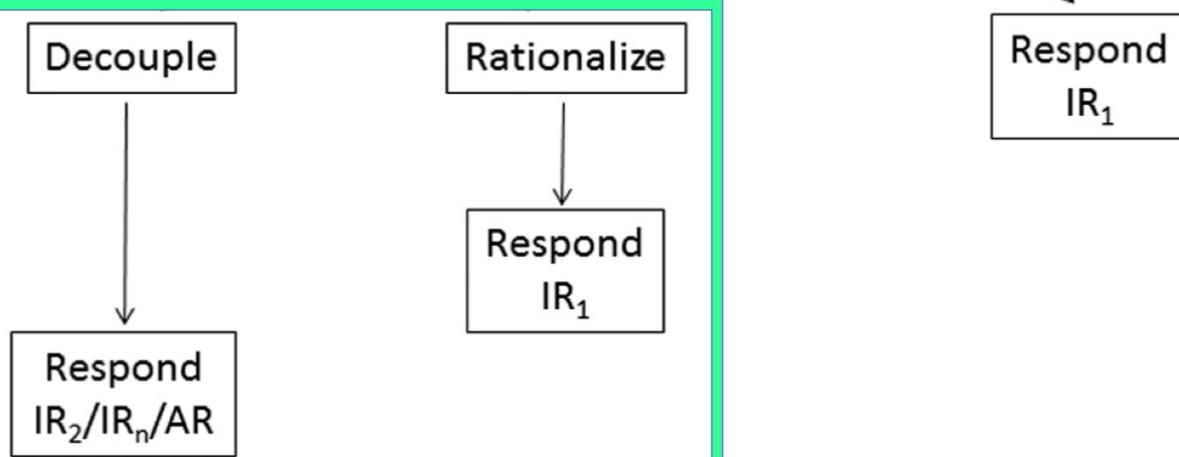
Stage 1:
Initial (T1)
Response
Generation



Stage 2:
Conflict
Monitoring



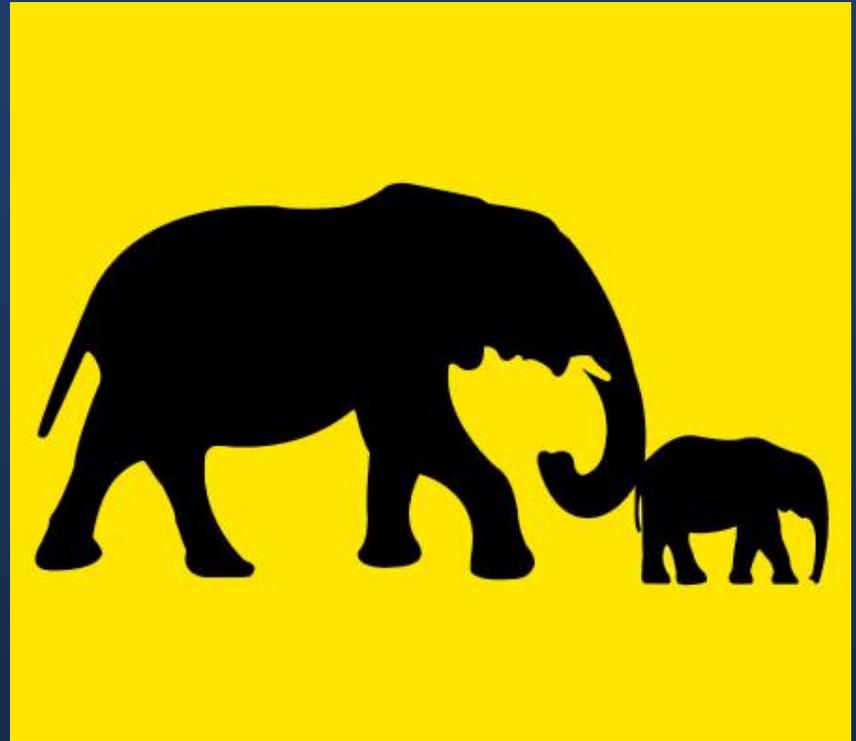
Stage 3:
Final (T2)
Response
Selection/
Generation



ANALYTICAL
THINKING

“A nudge...is any aspect of the **choice architecture** that alters people's behavior in a **predictable** way **without forbidding any options** or significantly changing their economic incentives... **Nudges are not mandates.** Putting fruit at eye level counts as a nudge. Banning junk food does not.”

- Thaler and Sunstein



Nudges

Nudges Do Not Require Cognitive Engagement

- Defaults
 - Automatic enrollment in programs (donor networks)
- Use of social norms
 - “Most providers wash their hands...”
- Increase in ease and convenience
 - Positioning of desirable products



Nudges may be planned or unplanned

- Sludges are nudges that
 1. Discourage behavior in a person's best interest
 2. Encourage self-defeating behavior
- Decisional friction can act as a nudge or sludge



Nudge vs. Sludge

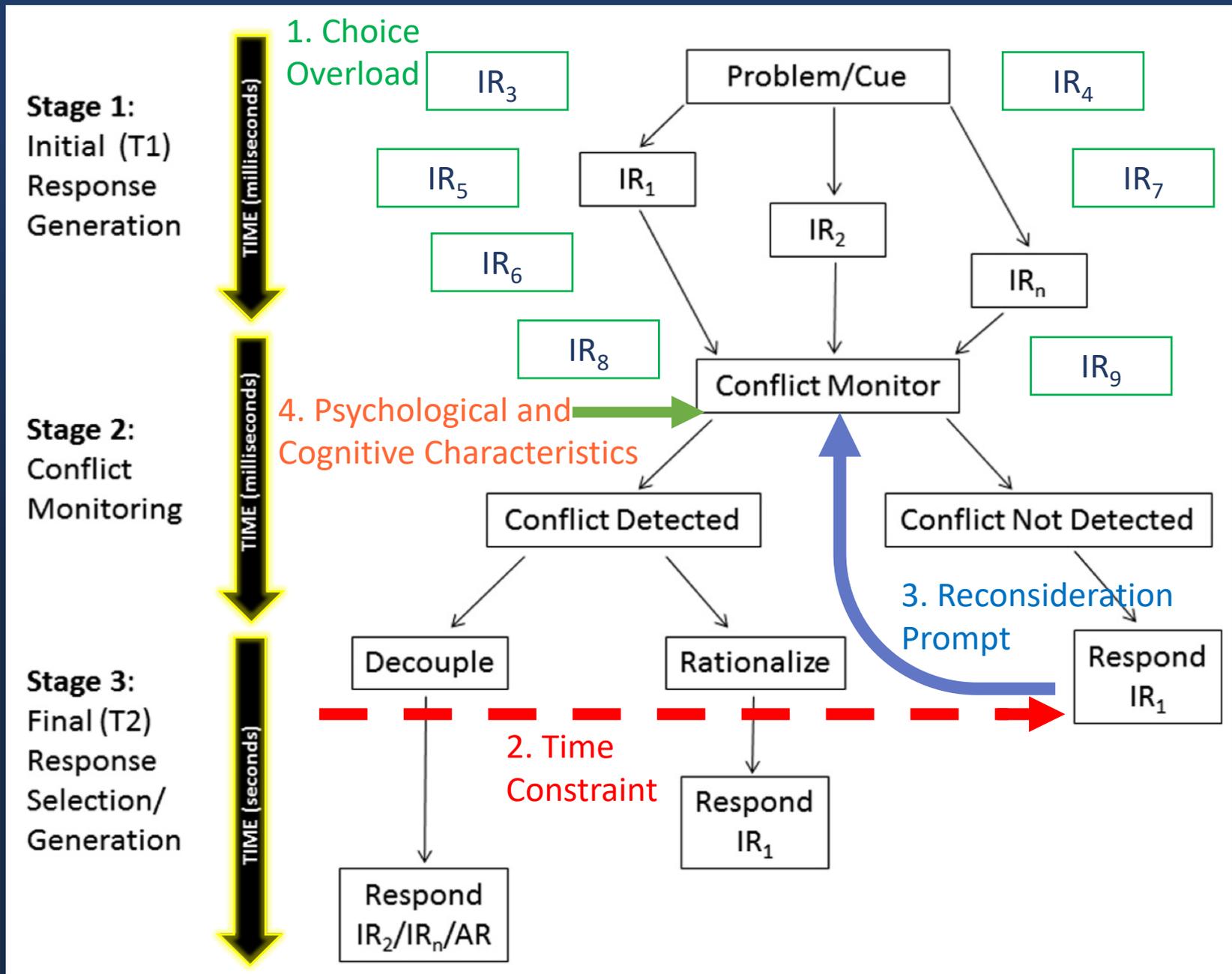


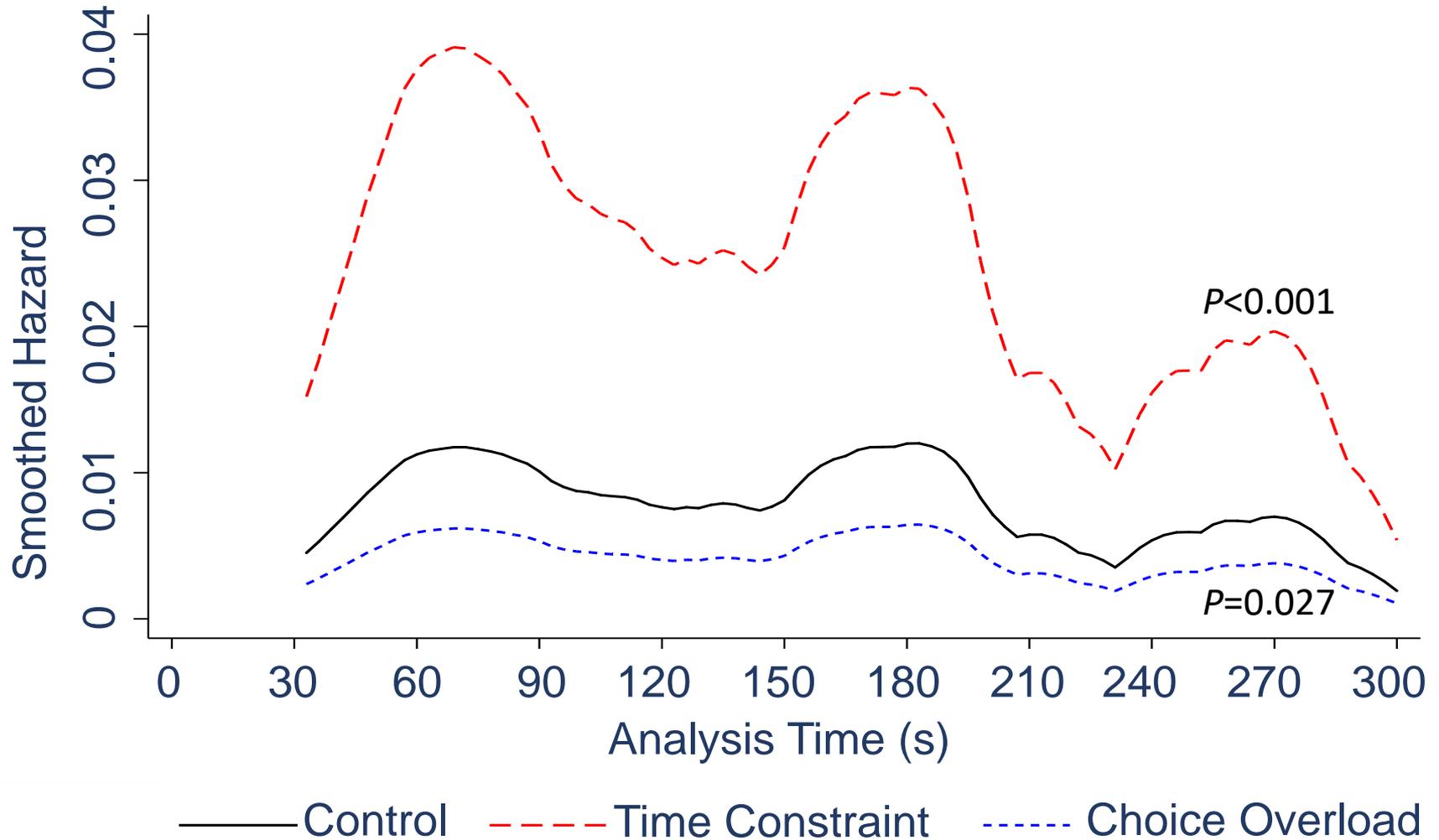
Table 1. Case Vignette and Answer Sets by Intervention Group

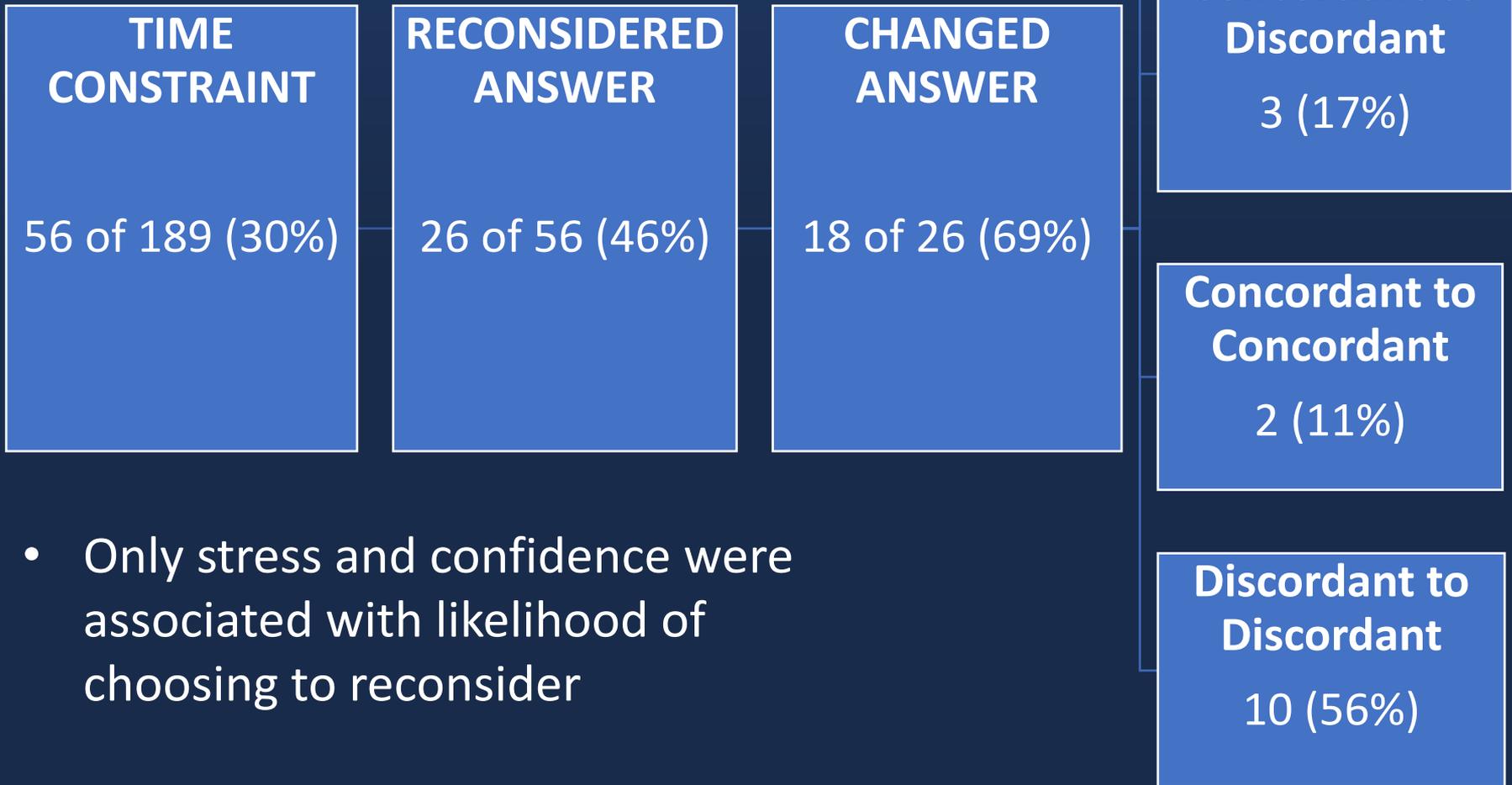
Case Vignette				
<p>A 60-year-old patient with a history of coronary artery disease and congestive heart failure (ejection fraction of 35%) presents with a chief complaint of shortness of breath. Two hours after an initial 500mL bolus of Normal Saline, on examination the temperature is 38.5°C, blood pressure 80/50 mmHg, pulse 100/min, and respiratory rate 22/min. Saturation on 2L of oxygen via nasal cannula is 96%. The patient weighs 66kg. The lower extremities demonstrate trace pitting edema to the knee. Cardiovascular and abdominal exam are otherwise normal. Lung exam reveals left basilar crackles. Laboratory exam reveals a leukocyte count of 15,000/mm³ (15.0 x 10⁹/L). Lactate is 4.2 mmol/L and sodium is 131 mEq/L (131 mmol/L). The remainder of the electrolytes are normal. A portable chest x-ray demonstrates cardiomegaly and faint left lower lobe patchy airspace opacities without prior films for comparison.</p>				
Which of the following would you prescribe over the next hour?				
Control	Time Constraint^a	Choice Overload		
I would not prescribe any additional IV fluids at this time	I would not prescribe any additional IV fluids at this time	I would not prescribe any additional IV fluids at this time		
250mL NS	250mL NS	250mL NS	1,250mL NS	2,250mL NS
500mL NS	500mL NS	250mL LR	1,250mL LR	2,250mL LR
1,000mL NS	1,000mL NS	500mL NS	1,500mL NS	2,500mL NS
1,500mL NS	1,500mL NS	500mL LR	1,500mL LR	2,500mL LR
2,000mL NS	2,000mL NS	750mL NS	1,750mL NS	2,750mL NS
		750mL LR	1,750mL LR	2,750mL LR
		1,000mL NS	2,000mL NS	3,000mL NS
		1,000mL LR	2,000mL LR	3,000mL LR

All answer choices were presented in random order. NS presented as 'Normal Saline' and LR presented as 'Lactated Ringers'.

^a 10 second limit imposed to select an answer choice. There was no limit for other intervention groups.

Choice Architecture Impacts Risk for Guideline Discordance

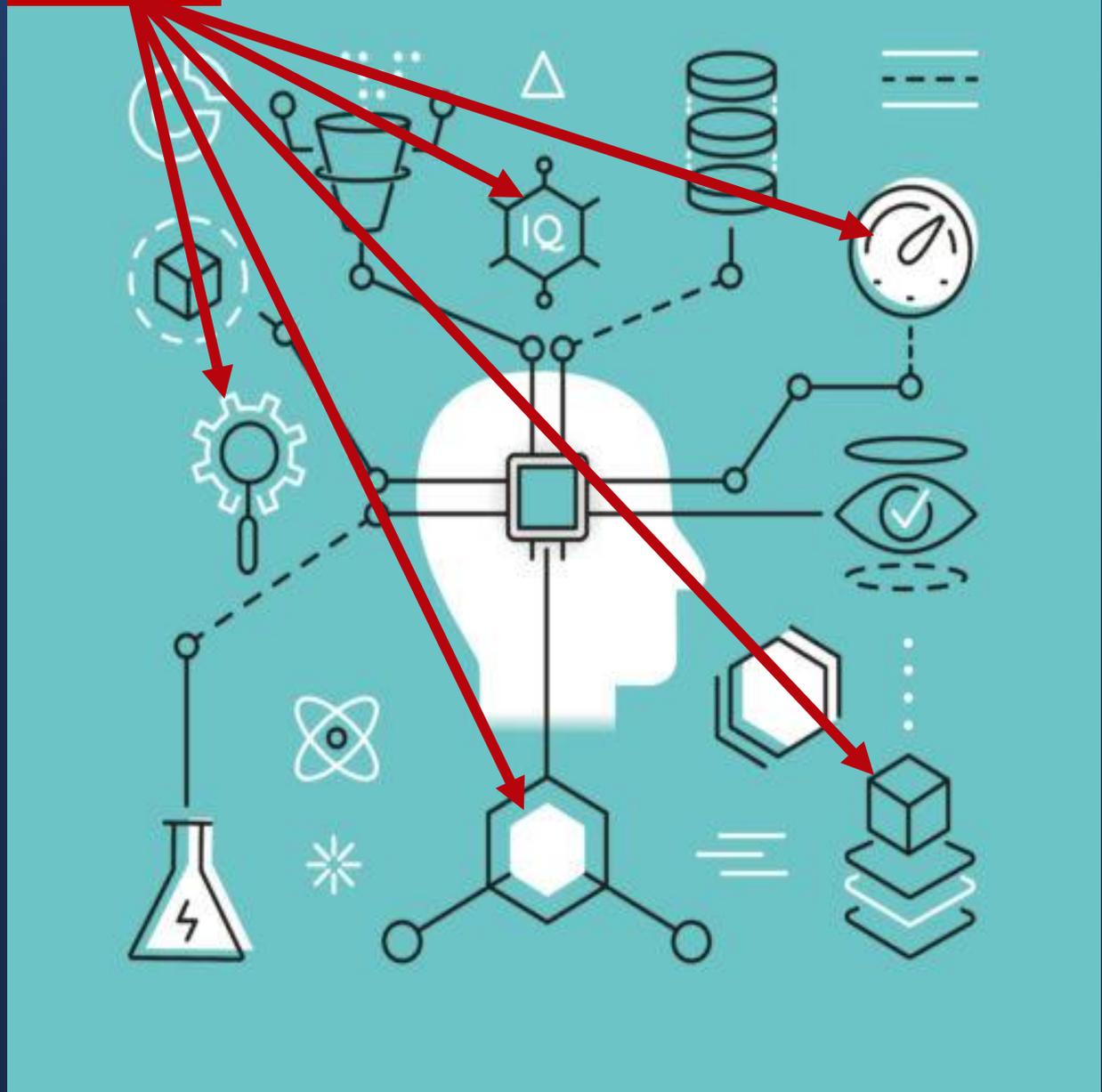




- Only stress and confidence were associated with likelihood of choosing to reconsider

Future Directions: A Mechanistic Approach to Nudging

Nudge



NHLBI K23 Proposal

Aim 1. To examine the mental models associated with fluid-resuscitation decisions for patients with septic shock in real-world contexts.

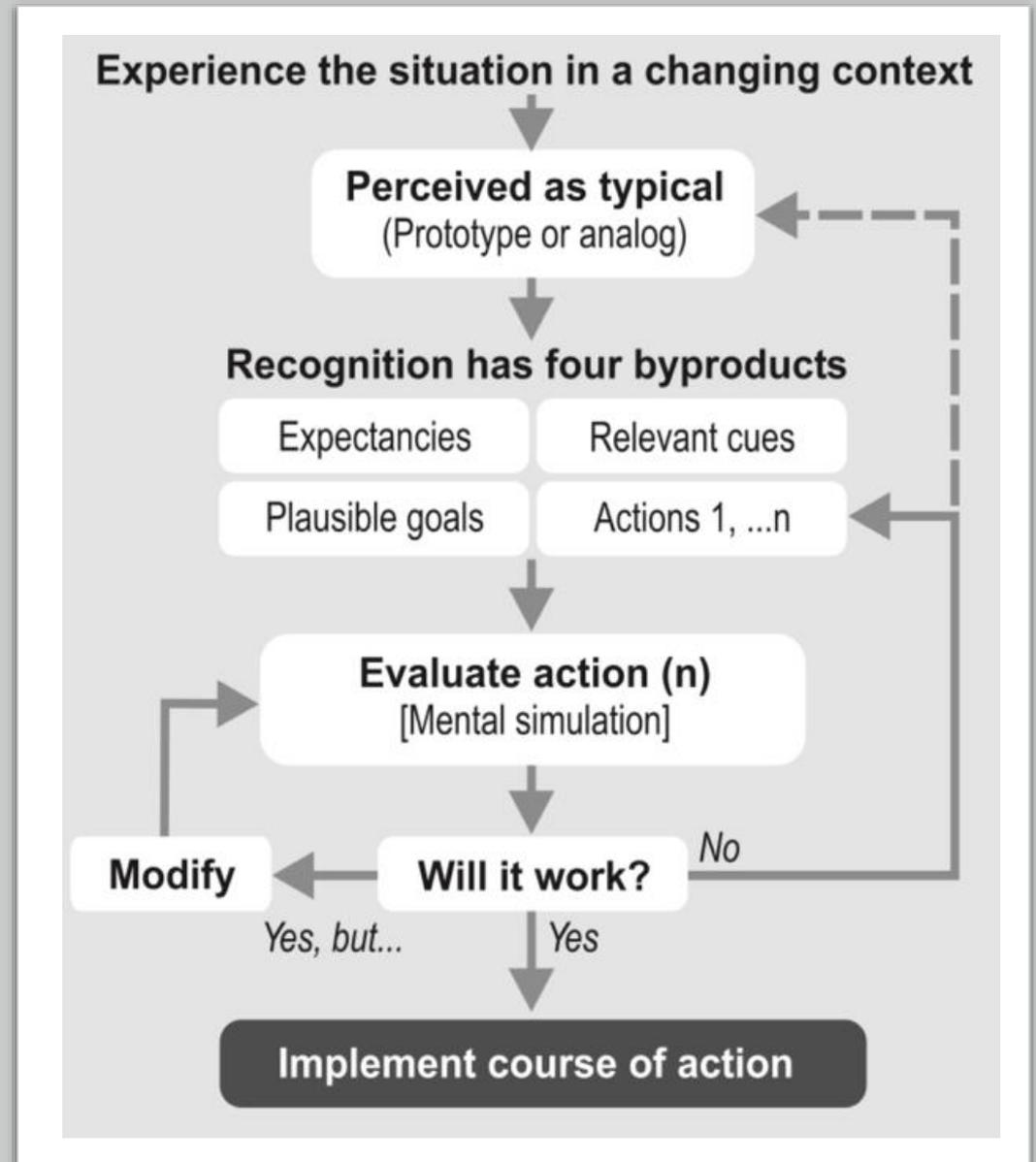
Aim 2. To measure the impact of clinician characteristics (demographic and psychological) and the choice environment on fluid-resuscitation decisions for patients with septic shock.

Aim 3. Informed by decision psychology, to a) develop and b) pre-test feasibility and effectiveness of a clinical decision aid for fluid resuscitation of patients with septic shock.

Methods and Tools

- **Cognitive Task Analysis (CTA)**: Set of methods and techniques that specify the cognitive structures and processes associated with task performance
- **Critical Decision Method (CDM)**: Cognitive task analysis method that employs retrospective interviews and cognitive probes to incidents that required expert judgment or decision-making

Recognition-Primed Decision Model



Code Group	Code	Sub-Code
Perception and Knowledge	Cues	Behavioral Clinical Fluids Physical/Environmental
	Information	Needed Used
Mental Modeling	Decision Making	Decision Points Emotional Response Fatigue Feeling Busy/Overwhelmed Guidance Received Intuition Other Individuals Influences Rules for Choosing Time Spent Time-Pressure
	Decision Alternatives	Vasopressors
	Analogues	
	Expected Outcomes	Acknowledge if Correct or Incorrect Anticipated Consequences Mistakes
	Goals	Measures of Success or Failure

Intuition: Confirmation Bias

“...if you just got eight liters you basically should be resuscitated with that, and so I wouldn't be surprised if a straight leg test was negative. **And that would like confirm my clinical suspicion that I already had versus if he only had two to three liters I'm already suspicious that they might not have had enough fluid resuscitation. And if a straight leg test is negative I don't know that I trust it enough to not give him additional fluid...**”

“I've done that a little bit more often but I think also I mean the IVC I was talking to Mike the other day and he's like **you kind of find what you're looking for when you're looking at the IVC.**”

Heuristic: 3-5 Liters

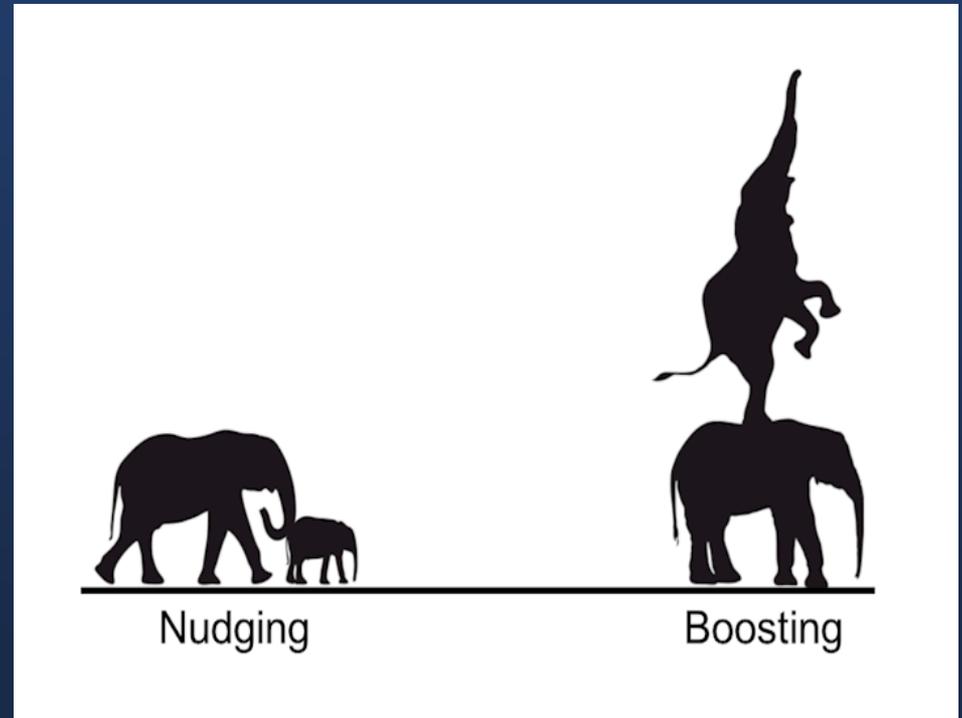
Interviewer 2: And why three to four?

Interviewee: That's arbitrary. I've gotten, I don't know. I have, no; it just feels like, yeah, I don't really know. It just feels like - that just feels like a number maybe my head where I'm just like that seems enough fluid....

Interviewer 2: Is it just a feeling that three to four is a lot or have you had other experiences that demonstrated to you that three to four was a lot or any specific reason that you chose those numbers?

Interviewee: I don't know like a specific. I just feel I guess in my head saying someone got five liters of fluid or four liters of fluid sounds like a lot and at least I feel at that number if you're not seeing a benefit I feel that's an appropriate therapeutic trial for someone with fluid. Whereas, if I hear someone got three liters in my head, it just feels to me, yeah, they could probably, maybe they could use a little bit more, that doesn't feel as significant. I guess there's just something about that four or five arbitrary threshold where in my mind that makes me a little bit more suspicious that we're just throwing stuff at them without any objective idea of what we're doing.

- “Smart Heuristics” – designing environments to trigger successful heuristic strategies
 - Support decision-making **without steering decisions** in a different direction
 - Particularly useful **in time-pressured** contexts with decisional **uncertainty**



Boosts

Boosts are 'Ecologically Rational'

- Reduce effort without sacrificing accuracy by matching the mind's capacities with the current environment
 - Less information as opposed to more information
 - Can outperform complex algorithms in real-world settings

Building Blocks of Boosts

- **Guiding Search**
 - Ordered search for cues and alternatives
 - Eg. Highest sensitivity predictor comes first



Building Blocks of Boosts

- **Stopping Search**
 - Simple criteria that are easily ascertained
 - Stopping rules do not try to compute an optimal cost-benefit trade-off



Building Blocks of Boosts

- **Decision-Making**
 - Simple principles
 - Do not require extensive computations and knowledge



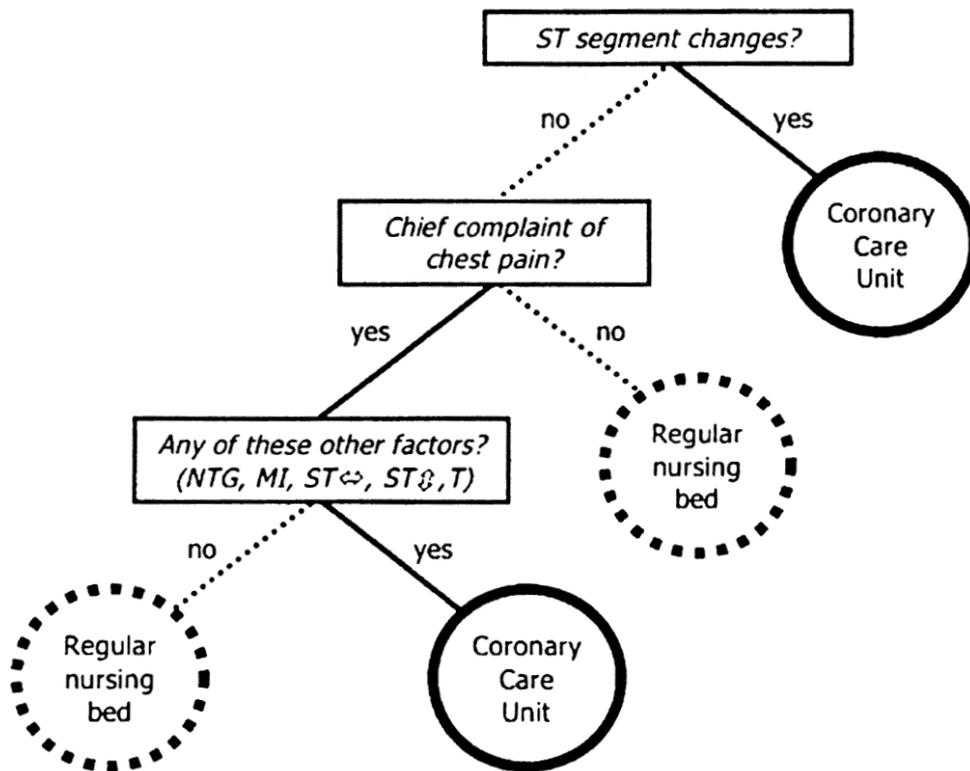
Decision-Making in Different Environments

- Noncompensatory – Importance of available cues are exponentially decreasing
 - Simple 'Take the Best' heuristic can outperform any optimal linear combination of binary cues (Martignon and Hoffrage, 1999)
 - One-Reason Decision-Making

Example of a 'Fast and Frugal' Decision Tree

Figure 1.2

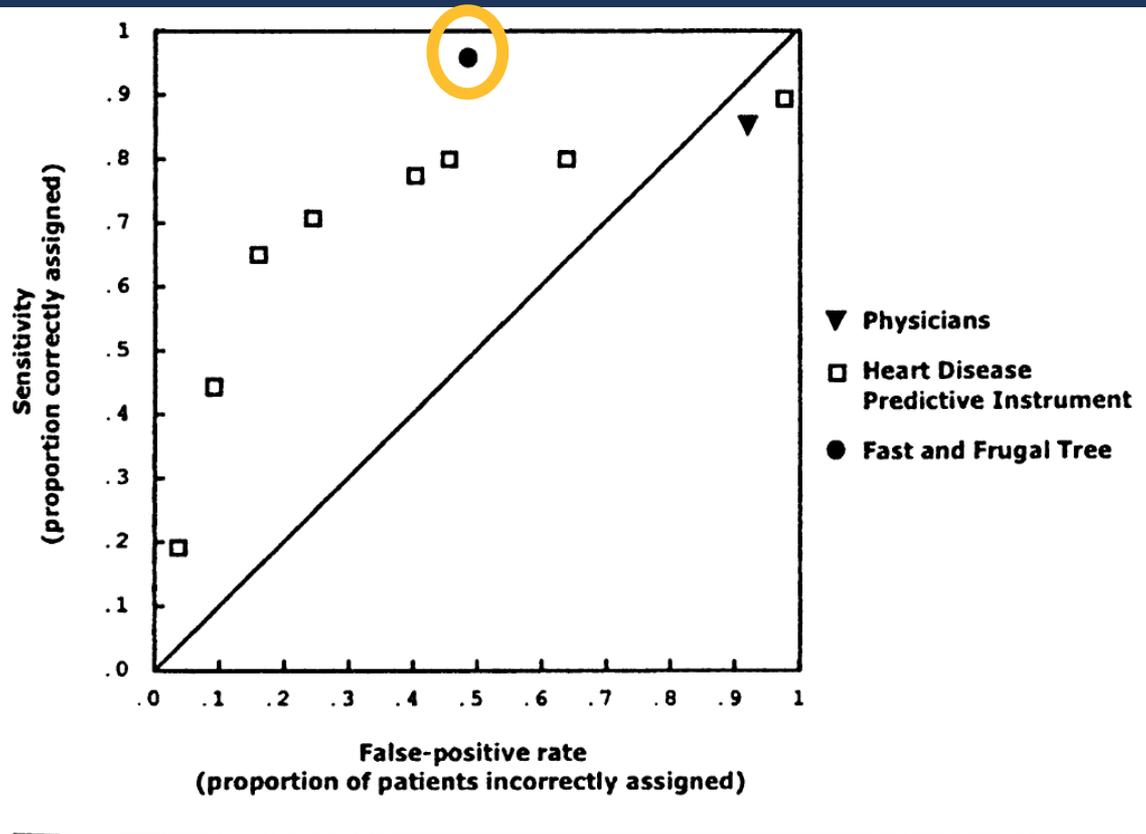
Fast and frugal decision tree for coronary care unit allocation. For explanations, see Figure 1.1.



Source: Based on Green & Mehr, 1997.

- Small number of binary predictors that allows for a decision at each branch of the tree

Clinician Intuition and Regression Model Outperformed by the Simplified Algorithm



Source: Based on Green & Mehr, 1997.

Decision-Making in Different Environments

- Compensatory – Can be exploited using a **tallying heuristic**
 - For example, if n ($n \geq 2$) then do X
 - Does not employ one-reason decision-making
 - Uses more than one cue
 - Simplicity lies in use of **only a few cues without ordering or weighting**

When Might Less Actually be More?

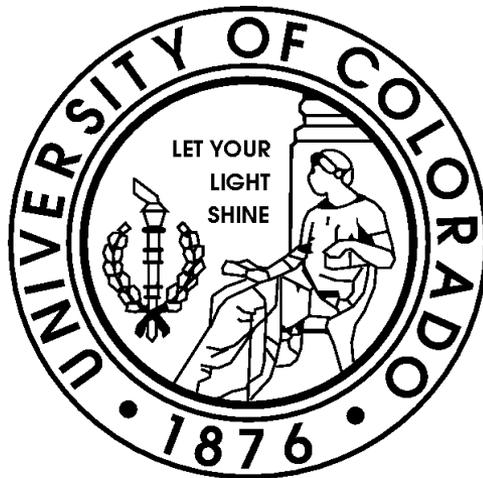
- Situations where **decisions are liable to error and generalization is poor**
 - **Overfitting** – noise and idiosyncrasies are explained by variables that do not generalize to new samples
- The more unpredictable the situation, the more information should be ignored



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— est. 1860 —

FOR LIFE'S JOURNEY



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