

Objective, Quantitative, and Theory-Driven Understanding of Cognition and Decision-Making

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Effective Interventions Require Precise Measurement

Verbal theories can only take us so far.

Precise, real-time, objective measurements can:

1. Support large-scale and automated interventions.
 2. Individually target interventions and other actions.
 3. Coherently integrate across human and AI actors.
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Mathematical Models of Human Cognition

Our team develops mathematical models which explain and predict human cognition and behavior. The models capture phenomena such as biases, limitations, and individual differences. We use Bayesian methods to estimate the models from data. This can guide interventions and defences.

Cognitive Psychology at Newcastle

Ranked #1 Institution for Cognitive Science in Australia ([Nov 9th, 2022, "The Australian" p38](#))



Three Examples of Related Projects

- Human-bot teaming for cybersecurity defence
- Optimizing around human information processing limitations for military operators in augmented reality environments
- Quantifying the unknown-unknowns

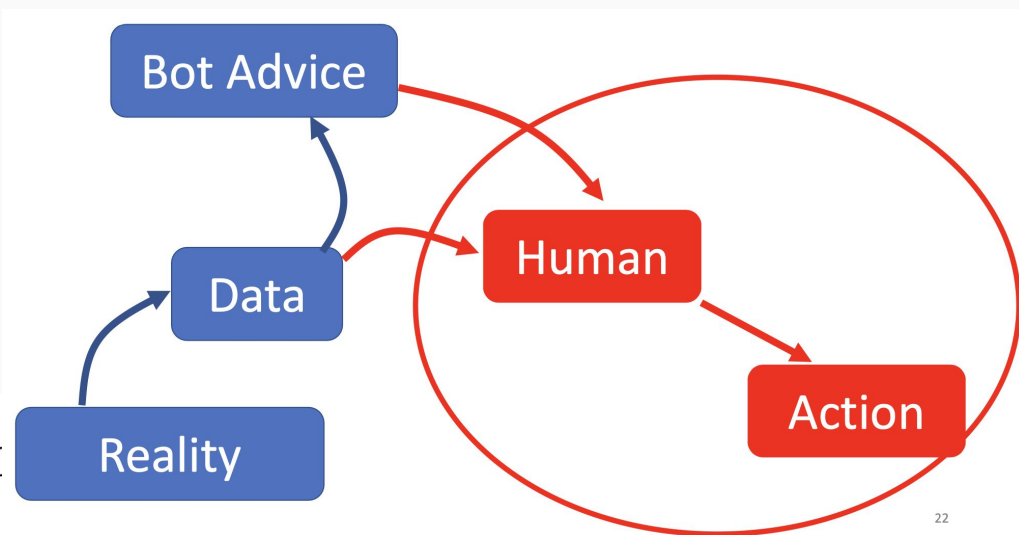
Human-bot teaming for cybersecurity defence

www.catch-muri.org - large team USA + Australia, computer scientists and cognitive psychologists, answering *how can human-bot teams work most effectively in cybersecurity defence?*

$$A_i \sim \mathcal{N}(T_i, \sigma_P^2 + \sigma_M^2)_{(I)}$$

$$R_i \sim \mathcal{N}(T_i, \sigma_R^2)_{(L,U)}$$

$$B_i \mid A_i, R_i \sim \mathcal{N}(\mu_i, \sigma_M^2)_{(L,U)}$$



Use something like a Kalman filter to understand human bias and human-bot trust

Optimizing for human information processing limitations of military operators in augmented reality environments

Work with Australian Army and multinational defence contractors.

Employ real-time measurement methods to understand cognitive performance of military operators.



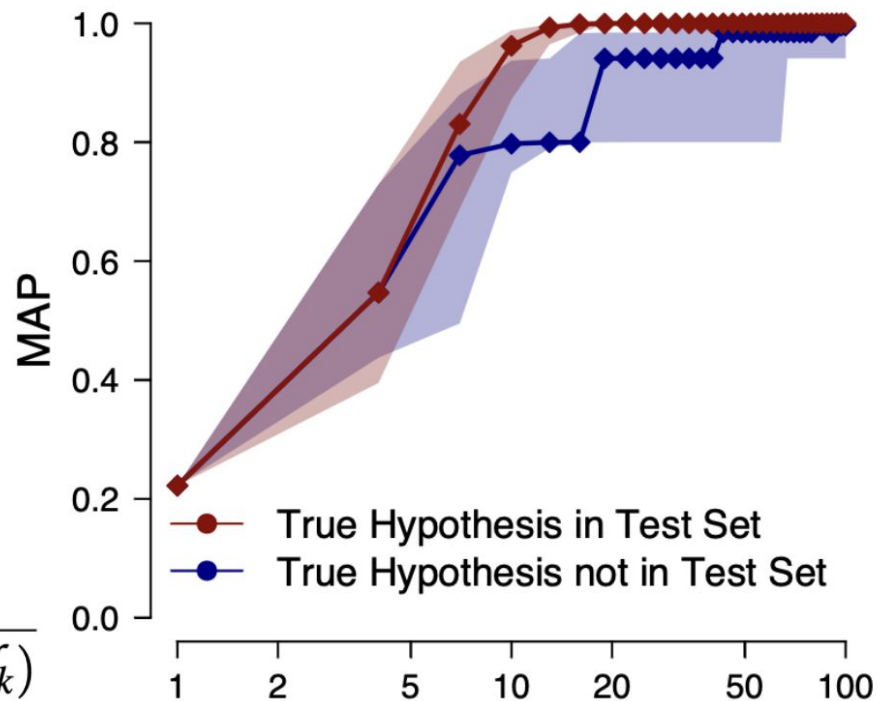
Quantifying the Unknown-Unknowns

How do we know, when we have failed to consider all the options?

This is critical for humans but also for AI algorithms with online monitoring responsibilities.

A meta-cognitive model based on Bayesian belief updating can help.

$$p(\mathcal{H}_j | \mathbf{y}) = \frac{p(\mathbf{y} | \mathcal{H}_j) p(\mathcal{H}_j)}{\sum_{k=1}^J p(\mathbf{y} | \mathcal{H}_k) p(\mathcal{H}_k)}$$



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ReSCIND

Cyber-attackers have the same biases and limitations as the rest of us. Accurately characterizing these allows interventions to be delivered at the right time, against the right targets.