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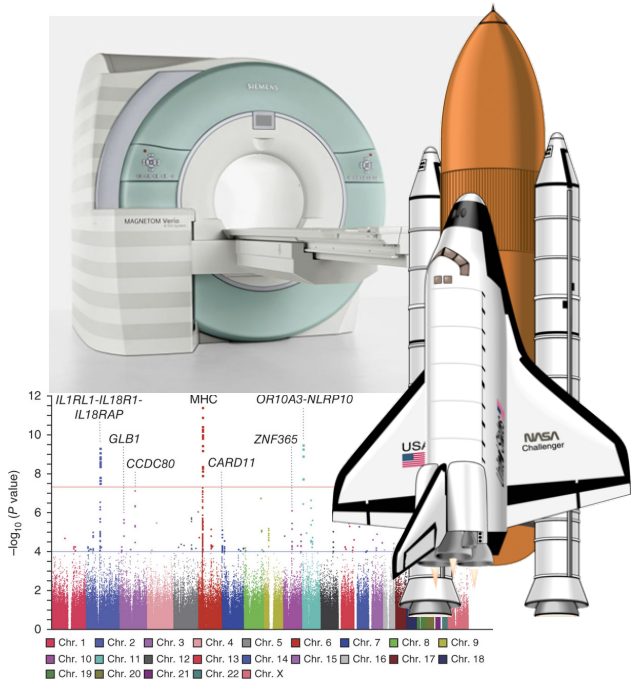
Current Opinion in Behavioral Sciences

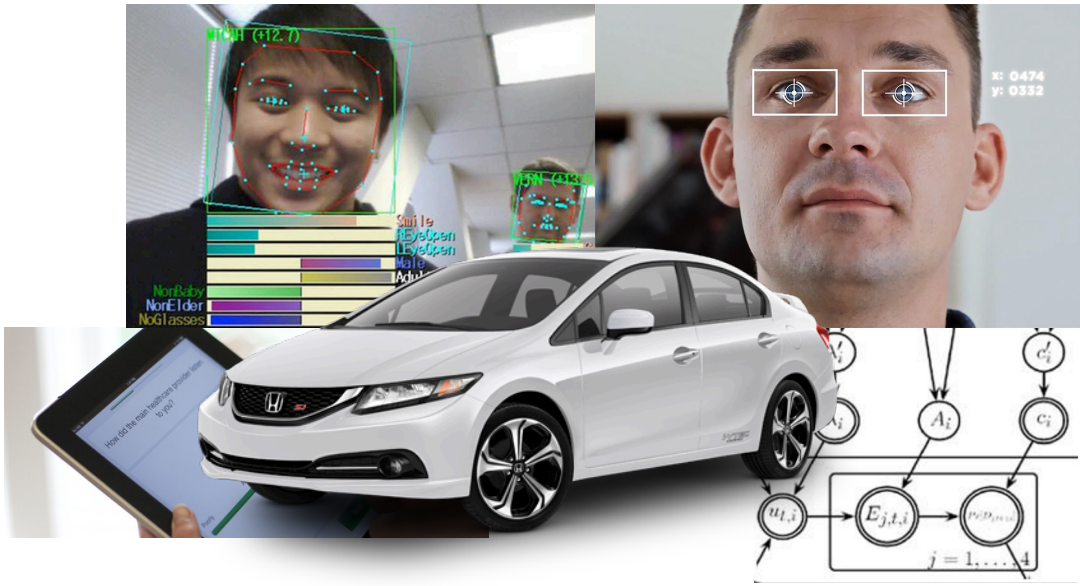
Challenges and promises for translating computational tools into clinical practice

Woo-Young Ahn[1] and Jerome R Busemeyer[2]

Woo-Young (Young) Ahn
PI, Computational Clinical Science Lab
The Ohio State University
June 16, 2016

Mission of the Computational Clinical Science Lab





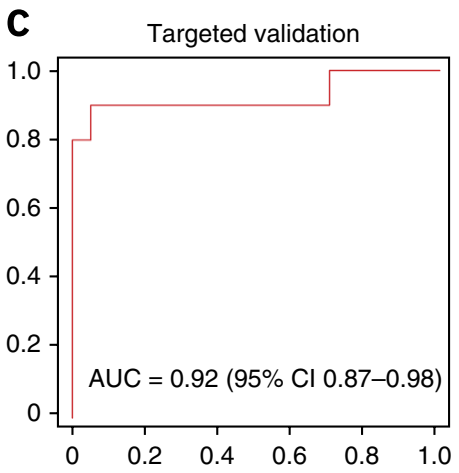
To maximize prediction accuracy

Affordable markers for clinical settings

Can we translate research into practice?

- Current diagnosis system
  - Interviews
  - Behavioral symptoms
- Identify who's at risk?

  Diagnostic tools



Mapstone et al (2014) Nature Medicine

What are the challenges and promises?

Money & Time

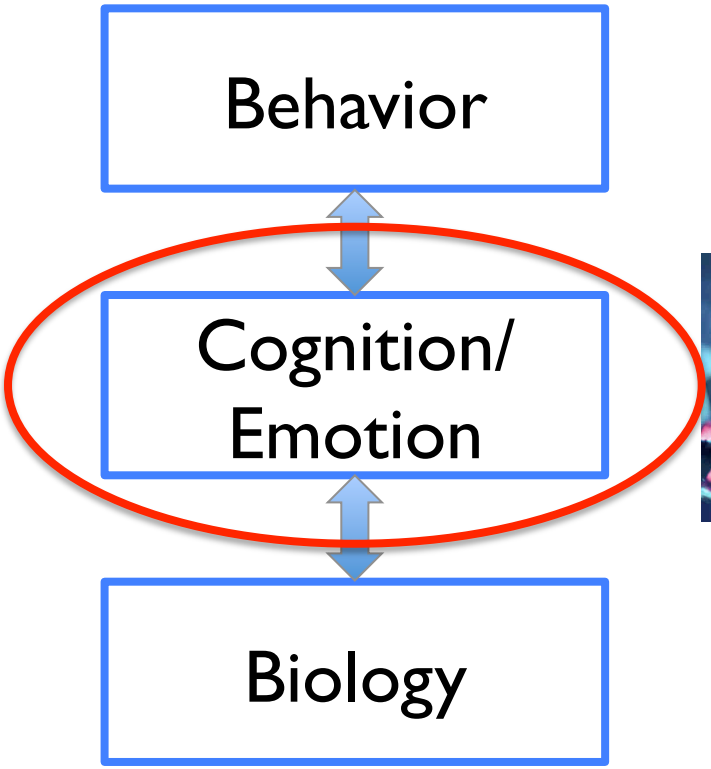
A. Precise characterization of latent neurocognitive processes
- Models of multiple decision-making systems
- Advanced data analytical methods including hierarchical Bayesian analysis
- Integration of behavioral and neural data

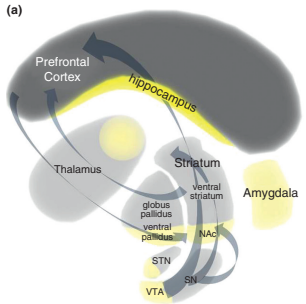
B. Optimal assays (i.e., paradigms) for assessing psychiatric conditions
- Theory-driven approach
- Clinical insights w/ external validity
- Adaptive design optimization (ADO)

C. Developing large-scale longitudinal studies & generating predictions from multi-modal data
- Collaborative consortia and workgroups
- Machine learning

(A) Precise characterization of latent neurocognitive processes

How to study latent (hidden) processes?





Volkow et al (2013)
Curr Opin Neurobiol

Is there a single framework for understanding the mind?

A framework for studying the neurobiology of value-based decision making

Antonio Rangel, Colin Camerer* and P. Read Montague†*

Rangel et al (2008) Nature Rev. Neuro

Review

Cell PRESS

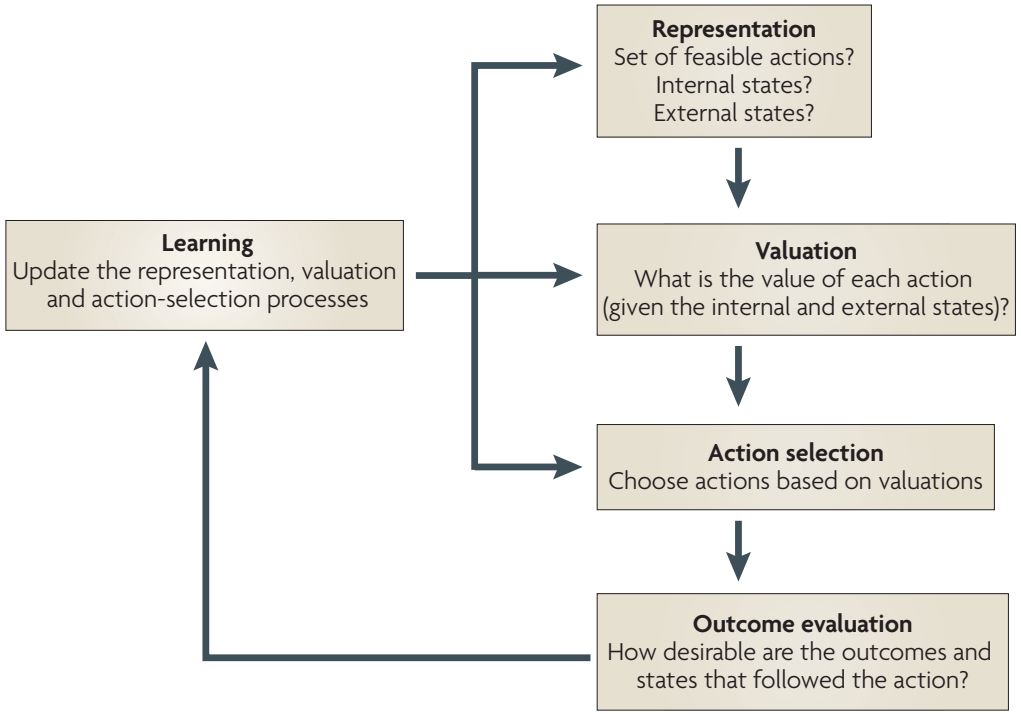
Special Issue: Cognition in Neuropsychiatric Disorders

Computational psychiatry

P. Read Montague[1,2], Raymond J. Dolan[2], Karl J. Friston[2] and Peter Dayan[3]

[1] Virginia Tech Carilion Research Institute and Department of Physics, Virginia Tech, 2 Riverside Circle, Roanoke, VA 24016, USA
[2] Wellcome Trust Centre for Neuroimaging, University College London, 12 Queen Square, London, WC1N 3BG, UK
[3] Gatsby Computational Neuroscience Unit, Alexandra House, 17 Queen Square, London, WC1N 3AR, UK

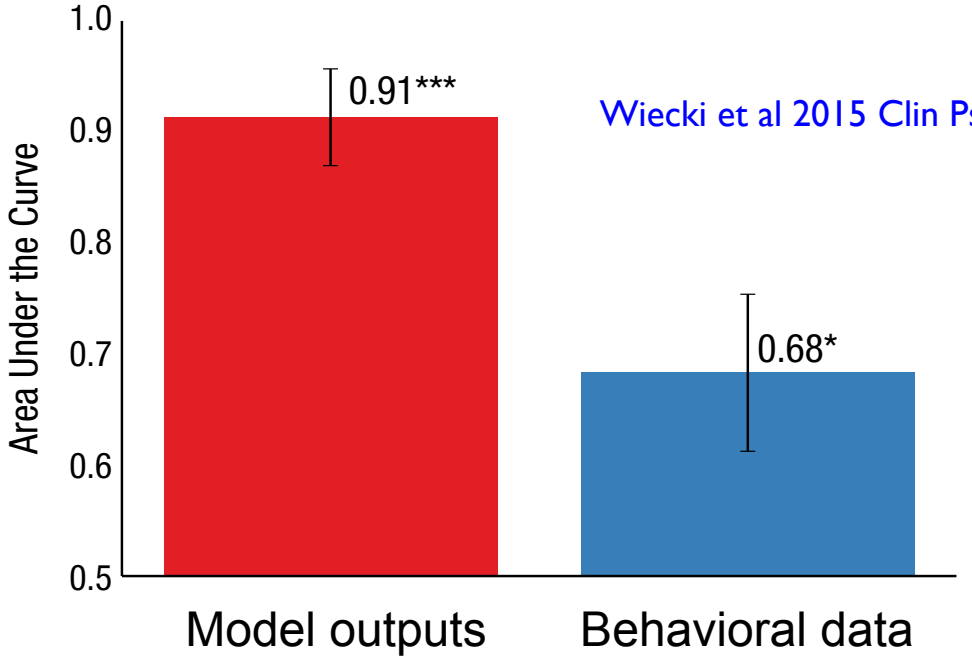
Montague et al (2012) Trends in Cog Sci



Rangel et al (2008) Nature Rev. Neuro

Computational Modeling

➔ *More information and greater prediction accuracy*



Wiecki et al 2015 Clin Psych Sci

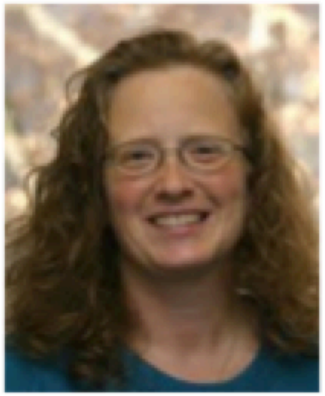
Wiecki et al 2015 Clin Psych Sci
Wiecki et al 2016 Plos ONE
Fridberg et al 2010 JMP

First started in Mathematical Psychology

William Batchelder

Roger Ratcliff

Richard Neufeld



Teresa Treat

Jerome Busemeyer

Batchelder (1998) Psychol. Assessment
McFall & Townsend (1998) Psychol. Assessment
Ratcliff (2000) PBR + many papers on aging, etc.
Neufeld (2002) Psychol. Assessment
Treat et al (2001) Psychol. Assessment
Busemeyer & Stout (2002) Psychol. Assessment
Yechiam et al (2005) Psych. Sci.

Utility of computational modeling for assessing clinical populations

"Computational Psychiatry"

Read Montague

Peter Dayan

Ray Dolan

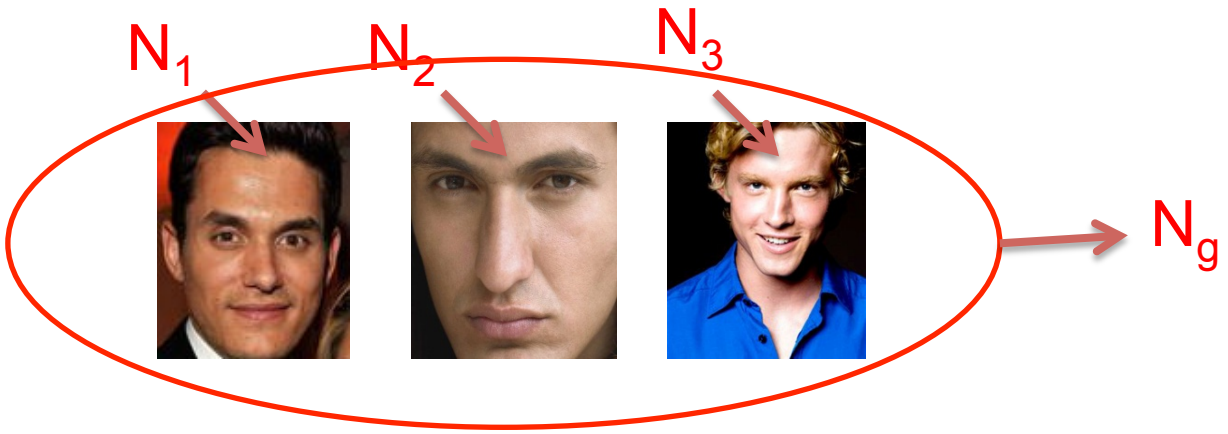
Karl Friston

Klaas Enno Stephan

Montague (2012) Trends Cog Sci
Dayan et al (2016) Curr Opinion Behav Sci
Friston et al (2014) Lancet
Huys et al (2015) Clin. Psychol. Sci.
Maia & Frank (2011) Nat. Neurosci
Wamg & Krystal (2014) Neuron
Stephan et al (2015) Neuron

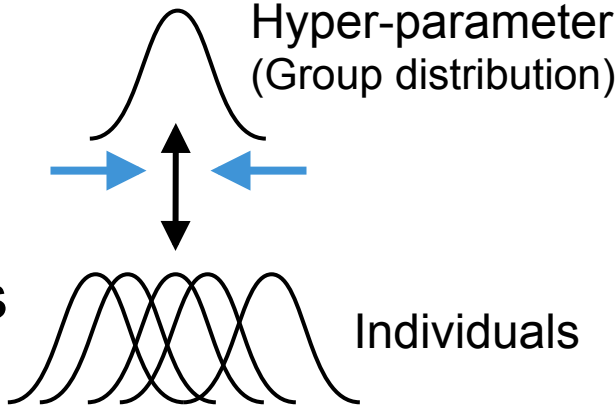
Computational accounts of abnormal cognition & its biological underpinnings

Hierarchical (Bayesian) analysis



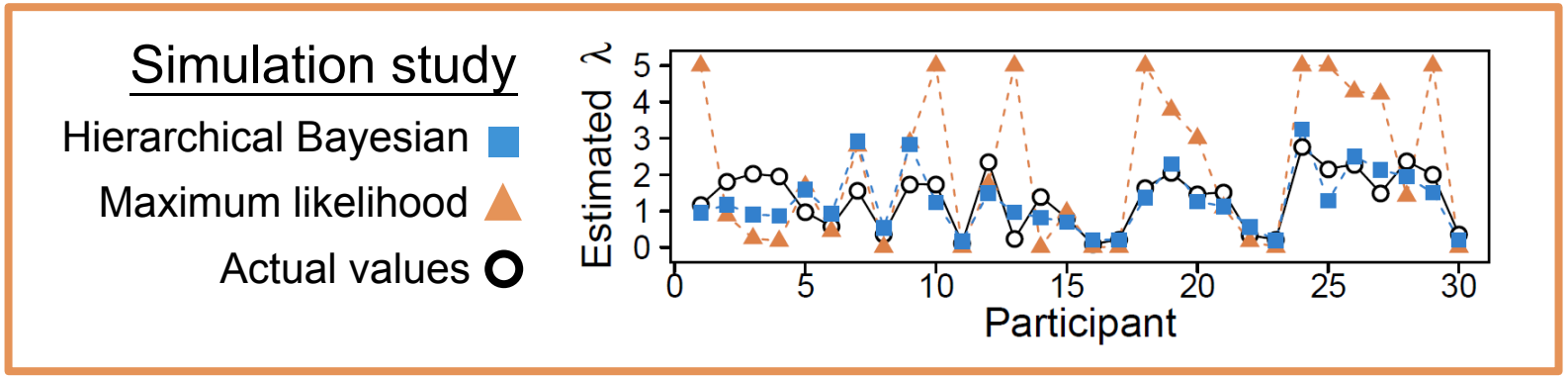
- Similarities & Differences

- Advantages of Bayesian data analysis



<u>Small amount of data from each subject but large N</u>

Hierarchical (Bayesian) analysis

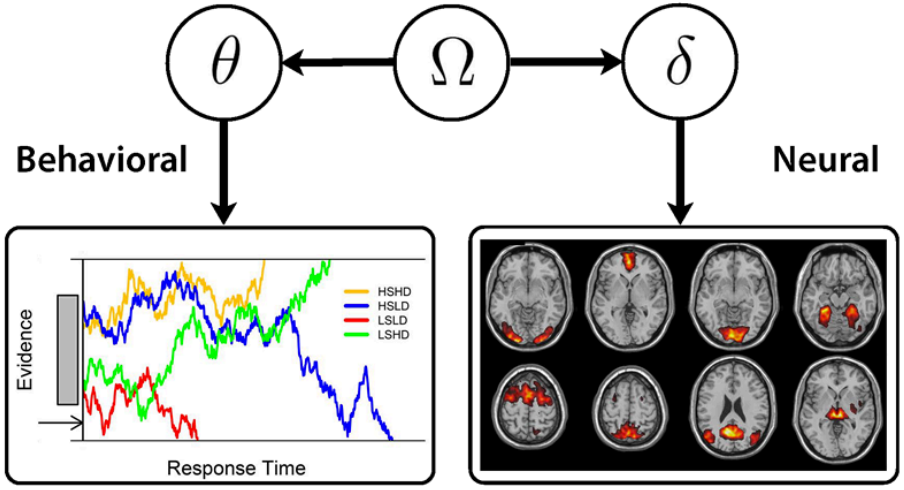


Ahn et al. (2011, JNPE)

(A lot) more room for improvement

- Single vs. multiple hyper groups
- Non-parametric Bayesian
- Data-driven clustering
- Accessibility

We can integrate behavioral and neural data in a single framework



Integrating behavioral and neural data in a single framework

Turner et al (2015) Psych Review
Turner et al (2013) Neuroimage

(B) Optimal assays (tasks) for assessing psychiatric conditions

Laboratory tasks

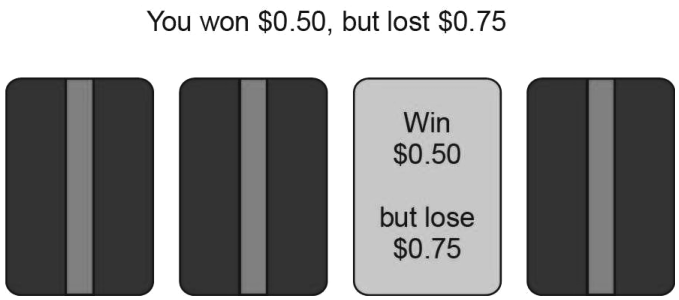
To mimic real-life decisions

Two different camps

1. Clinicians/psychologists
   - Develop/adopt emotionally engaging tasks
   - Mimic naturalistic risk-taking behaviors

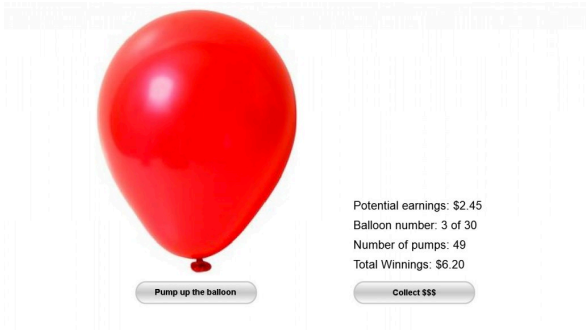
2. Economists/neuroscientists
   - Understanding specific constructs

Clinicians/psychologists



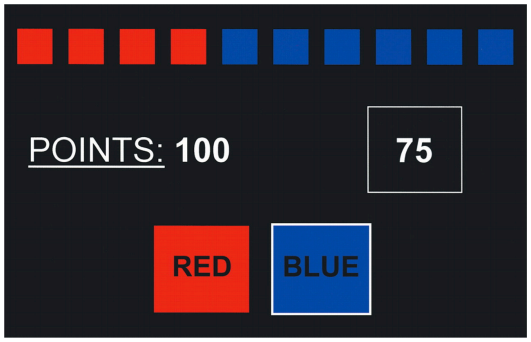
Iowa Gambling Task

Bechara et al (1999) Cognition



Balloon Analogue Risk Task

Lejuez et al (2002) JEP: Applied



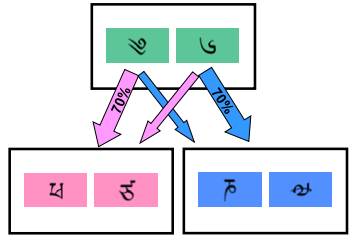
Cambridge Gambling Task

Rogers et al (1999) Neuropsychpharm.

Economists/neuroscientists

Orthogonal Go/Nogo Task

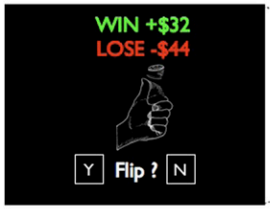
Guitart-Masip et al (2012) Neuroimage



Two-Step Task

Daw et al (2011) Neuron

Voon et al (2014) Mol. Psychiatry



Loss Aversion Task

Tom et al (2007) Science

De Martino et al (2010) PNAS

What are the pros and cons?

- Can we disentangle underlying processes?
- Emotionally engaging?
- Realistic for patient populations?

Both clinical expertise &

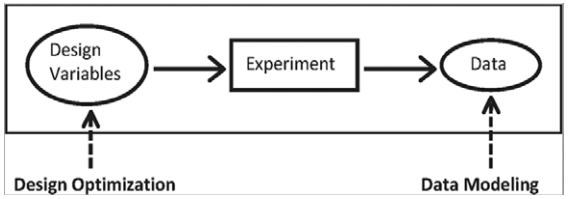
knowledge of neurobiology

Schonberg et al (2011) TiCS

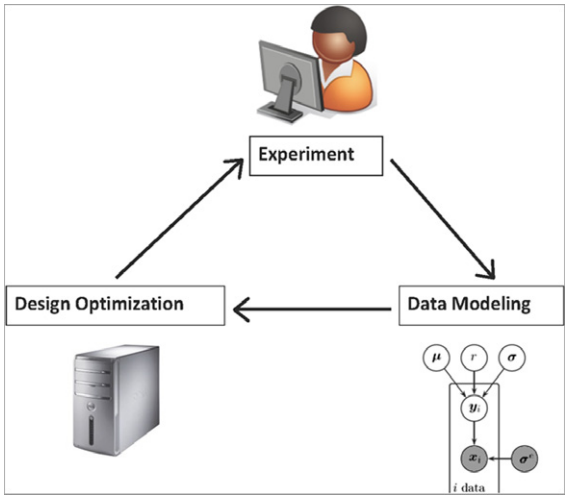
Can we optimize experimental design?

Myung et al (2013) JMP
Myung & Pitt (2009) Psych Review

$100 now **VS** $200 in 1yr?



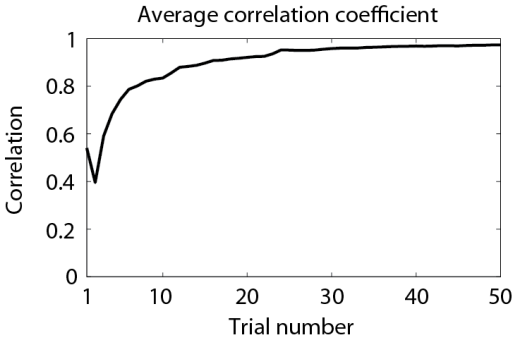
Traditional experimentation



ADO

ADO in action

Cavagnaro et al (2012) Management Sci
Cavagnaro et al (in press)

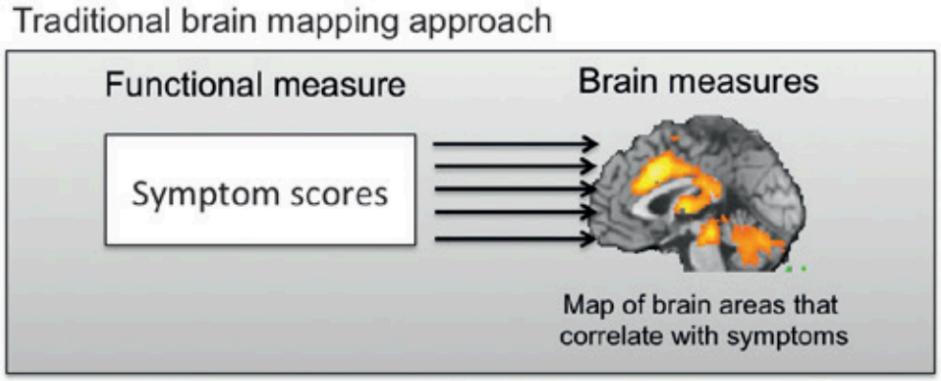


Test-retest reliability
Over 0.9 after 15 trials.

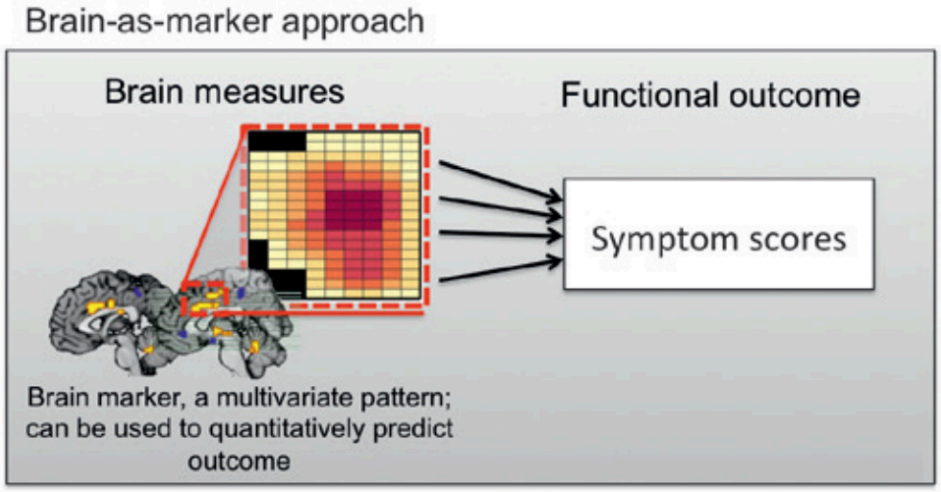
Hou et al (2016)

(C) Predictions using multi-modal & multi-dimensional data

How to make precise predictions?



Wager (2015)
Woo & Wager (2015) Pain
Wager & Woo (2015) Science Trans Med



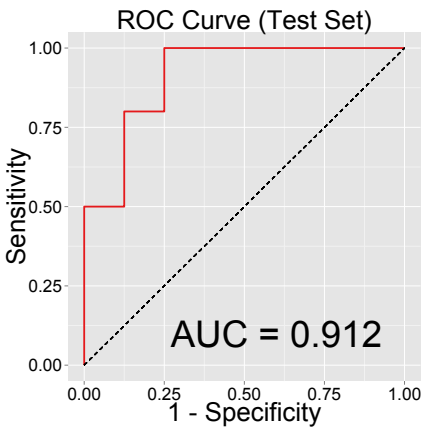
Ahn et al (2014) Curr Biol
Finn et al (2015) Nature Neuro
Gabrieli et al (2015) Neuron
Norman et al (2006) TiCS
Pereira et al (2009) Neuroimage
Poldrack (2008) Curr Opin Neurobiol
Wager et al (2013) NEJM
Whelan et al (2014) Nature

Example

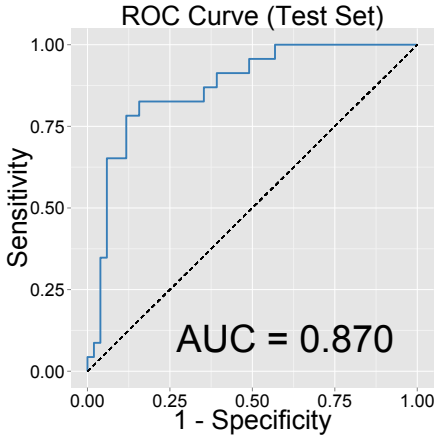
Neuropsychosocial profiles of current and future adolescent alcohol misusers

Robert Whelan[1,2], Richard Watts[3], Catherine A. Orr[4], Robert R. Althoff[5,6], Eric Artiges[7,8], Tobias Banaschewski[9], Gareth J. Barker[10], Arun L. W. Bokde[11], Christian Büchel[12,13], Fabiana M. Carvalho[10], Patricia J. Conrod[10,14], Herta Flor[9], Mira Fauth-Bühler[9,15], Vincent Frouin[16], Juergen Gallinat[12,17], Gabriela Gan[18], Penny Gowland[19], Andreas Heinz[17], Bernd Ittermann[20], Claire Lawrence[21], Karl Mann[9], Jean-Luc Martinot[7,22], Frauke Nees[9], Nick Ortiz[1,23], Marie-Laure Paillère-Martinot[17,22], Tomas Paus[24,25], Zdenka Pausova[26], Marcella Rietschel[9], Trevor W. Robbins[27], Michael N. Smolka[18], Andreas Ströhle[17], Gunter Schumann[10,28], Hugh Garavan[1,6,11] & the IMAGEN Consortium†

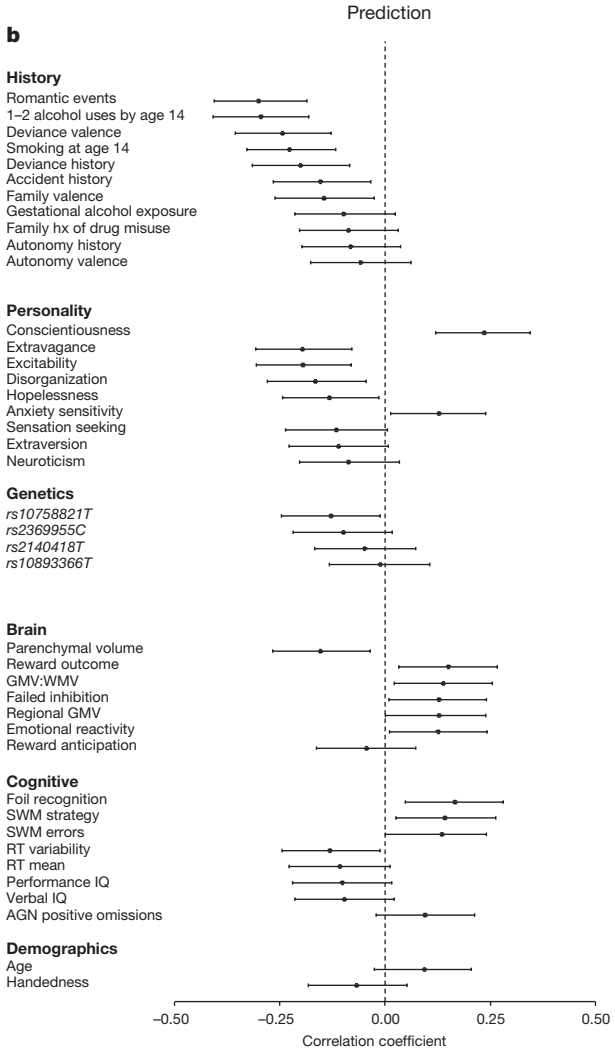
Whelan et al (2014) Nature

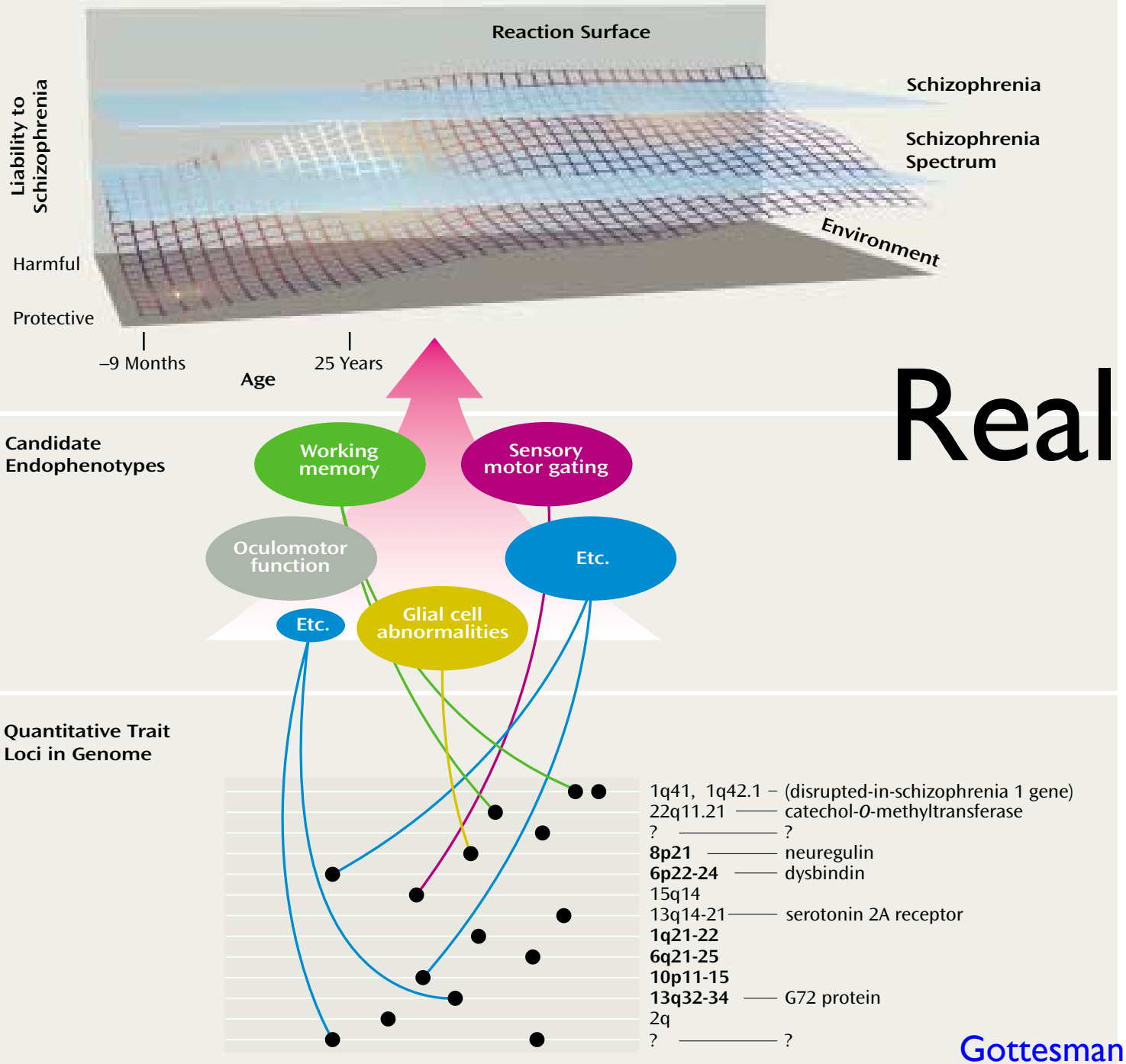


Ahn et al (2016) Frontiers Psychiatry



Ahn & Vassileva (2016) DAD



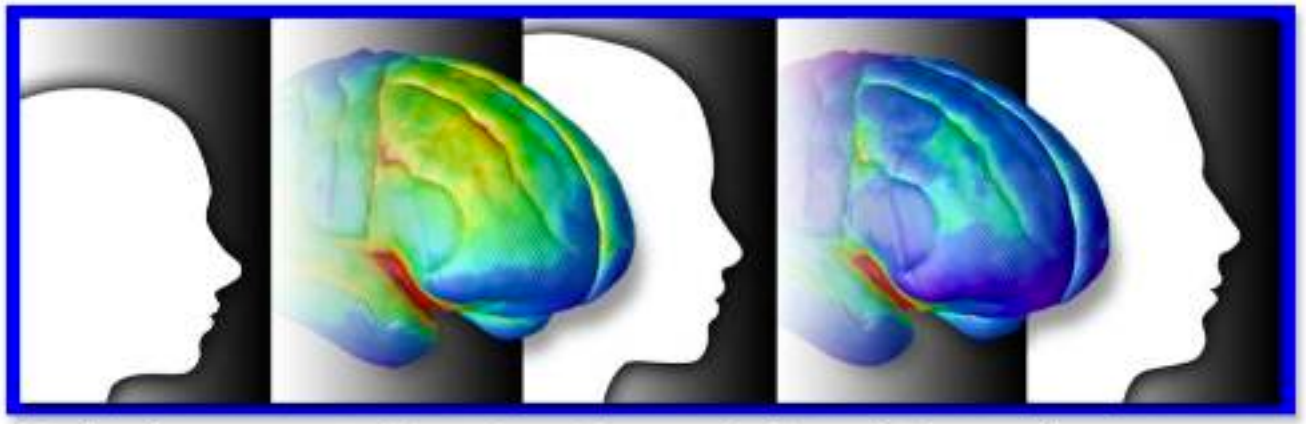


Reality…

Gottesman & Gould (2003) AJP

Longitudinal study

NIDA
NATIONAL INSTITUTE
ON DRUG ABUSE



Adolescent Brain Cognitive Development

- **10,000** adolescents over **10** years
- Data sharing

Conclusions

- *Cost-effective/surrogate markers*
- *Data/code sharing*
- *Education*
- *Collaboration across multiple disciplines*
- *A long way to go…*

Directions

Computational Clinical Science (CCS) Laboratory

Addictive Disorders

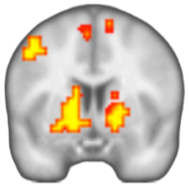
Novel insights/assessment

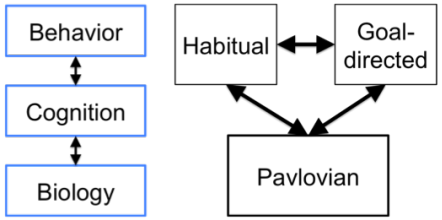
Individualized treatment

Biomarkers

Surrogate markers

Computational neuroscience





Machine learning

$$\hat{\beta} = \arg\min_{\beta}(||y - X\beta||^2 + \lambda_2||\beta||^2| + \lambda_1||\beta||_1)$$

Thank you!