From Classical to Computational Psychiatry

SPICE 2024

Neuroscience & Computational Psychiatry Module

Class III

Mount Sinai

Center for Computational Psychiatry

1st of July 2024

Psychiatric disorders & approaches to treat and study them

- What is a psychiatric or mental health disorder?
- What are classifications of psychiatric or mental health disorder?
- Why is the goal of computational psychiatry?
- What are the characteristics of computational psychiatry?

What is a psychiatric or mental health disorder?

Image: Adobe Stock

What is a psychiatric or mental health disorder?

What is a psychiatric or mental health disorder?

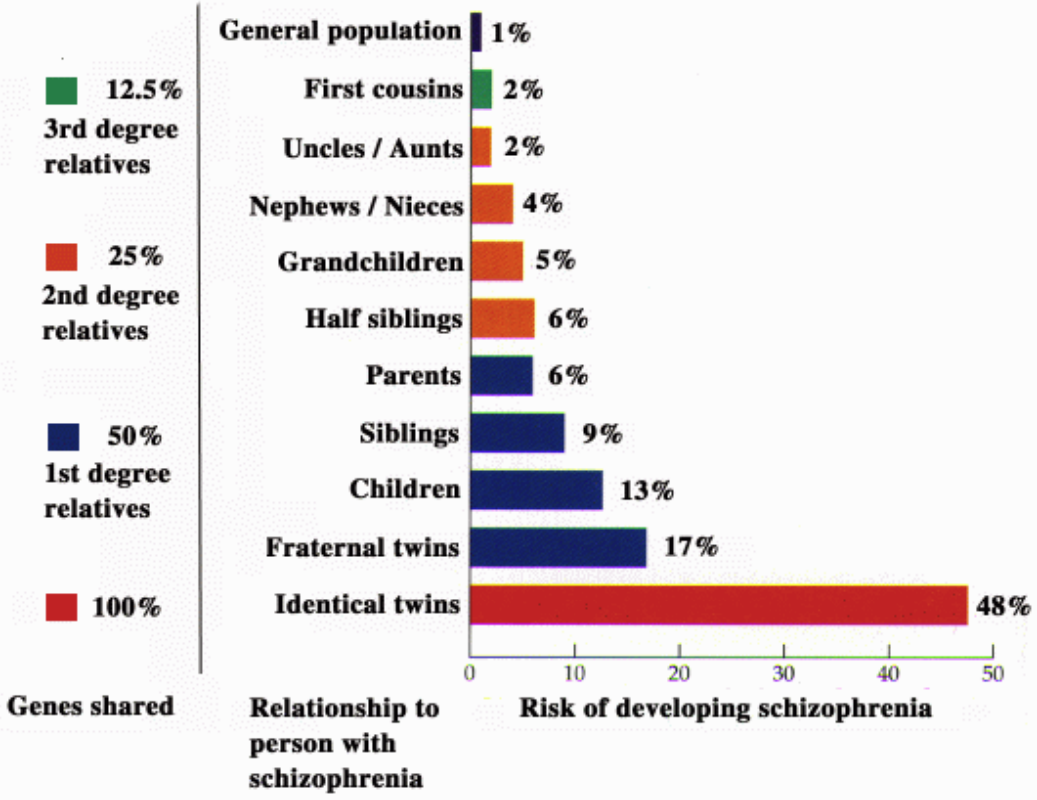
How do we know that mental illness has a biological cause?

- Genetic studies can tell us if a person's specific DNA may increase their risk for a given psychiatric disorder, over and above those factors in our environment (parents, household, school, diet, etc.).

- The effectiveness of biological therapies on mental disorders can also give evidence for a biological component to these disorders.

- Biological therapies include medications, shock treatment, and brain stimulation (though brain changes can occur with talk therapy as well).

What is a psychiatric or mental health disorder?

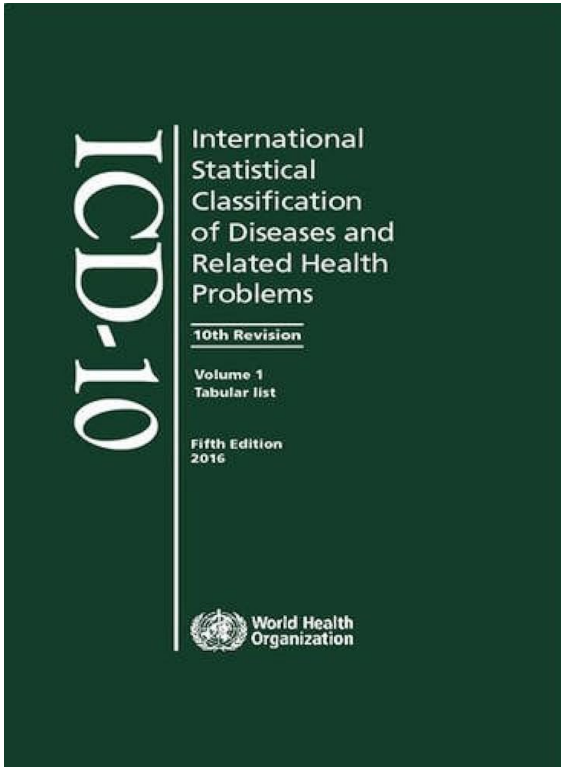


Gottesman, 1991

How do psychiatric disorder get diagnosed?

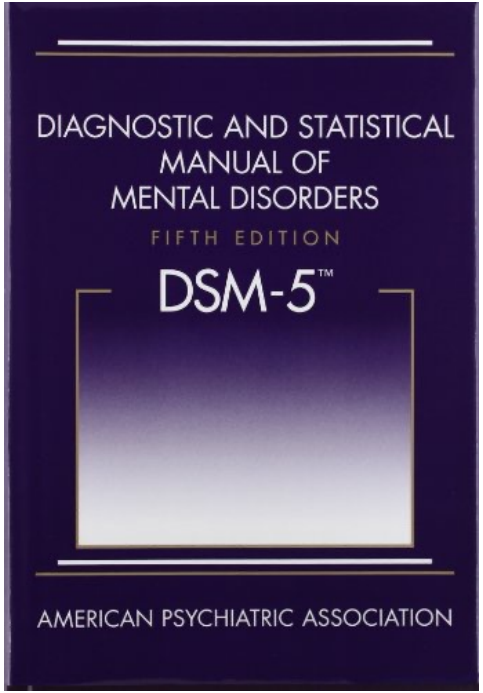
- Consensus agreement among experts

- ICD: International Classification of Diseases
- WHO – classification across all illnesses
- Categorical (healthy/ ill)
- Chapter F covers mental health



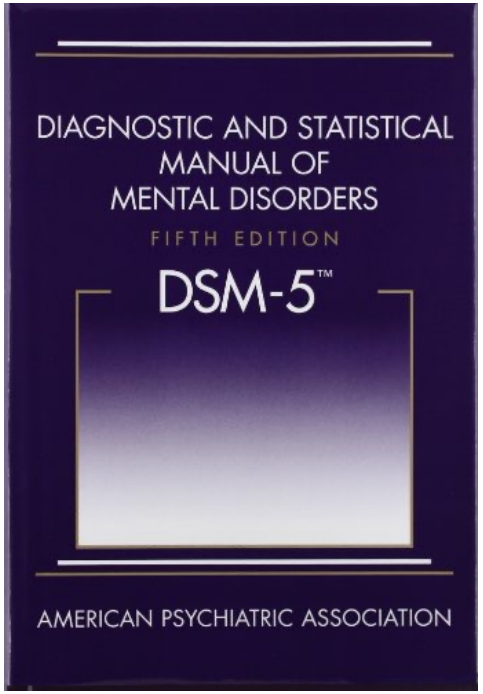
How do psychiatric disorder get diagnosed?

- Diagnostic and Statistical Manual of Mental Disorder (DSM)
- Fifth version
- Used in America
- Gold standard: interview with a trained clinician (clinical psychologist/ psychiatrist)

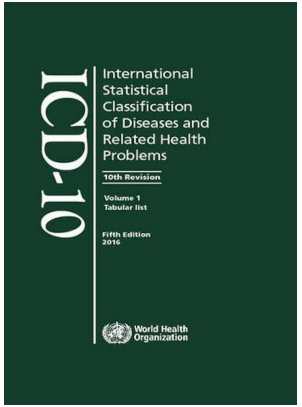


How do psychiatric disorder get diagnosed?

- Interview (semi-structured) which explores symptoms
- Symptoms cause clinically **significant distress** or impairment in social, occupational, or other important areas of functioning
- Episode not attributable to physiological effects of a substance or another medical/psychiatric condition

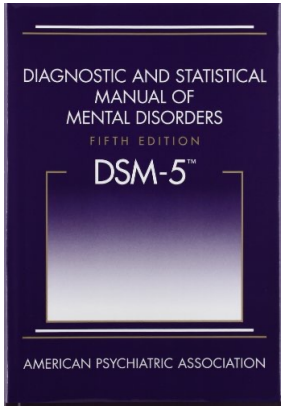


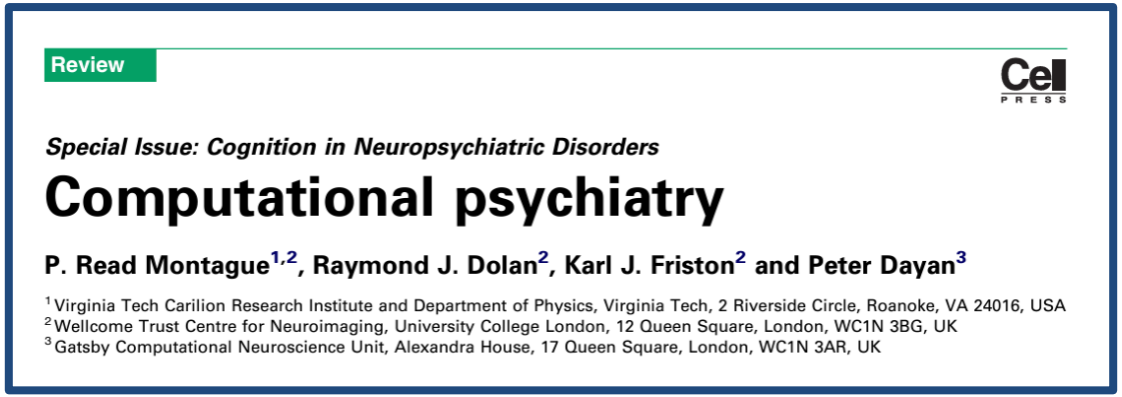
How do psychiatric disorder get diagnosed?



Both **schemes**

- reflect the consensus (or compromise) of expert committees
- **diagnoses are self-report-based**, reports of others (teachers, parents), observations in clinical setting
- are **descriptive** and based on overt symptoms (**without reference to mechanisms**)
- Many symptoms are present in **multiple disorders**





Review

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Special Issue: Cognition in Neuropsychiatric Disorders

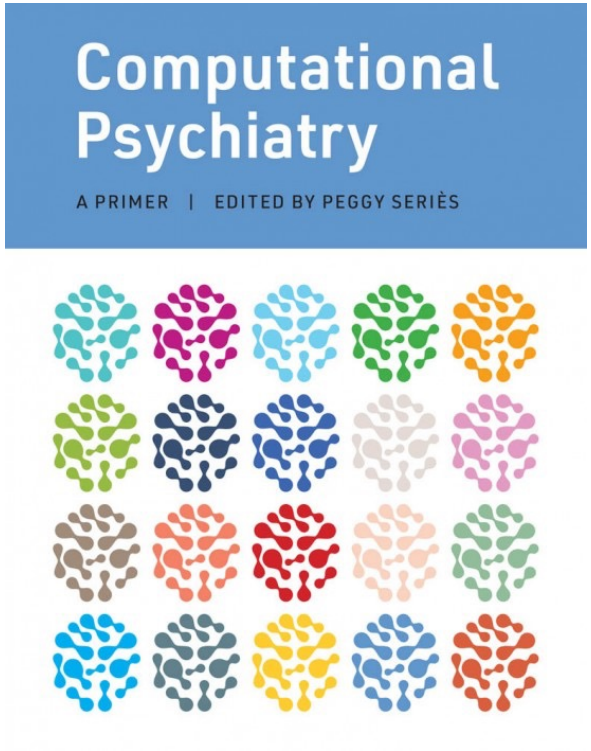
Computational psychiatry

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

1. How does computational psychiatry aim to improve the understanding of mental illnesses?
2. What role do games play in studying mental disorders?
3. What insights can be gained from studying decision-making games in mental health research?

What is Computational Psychiatry?



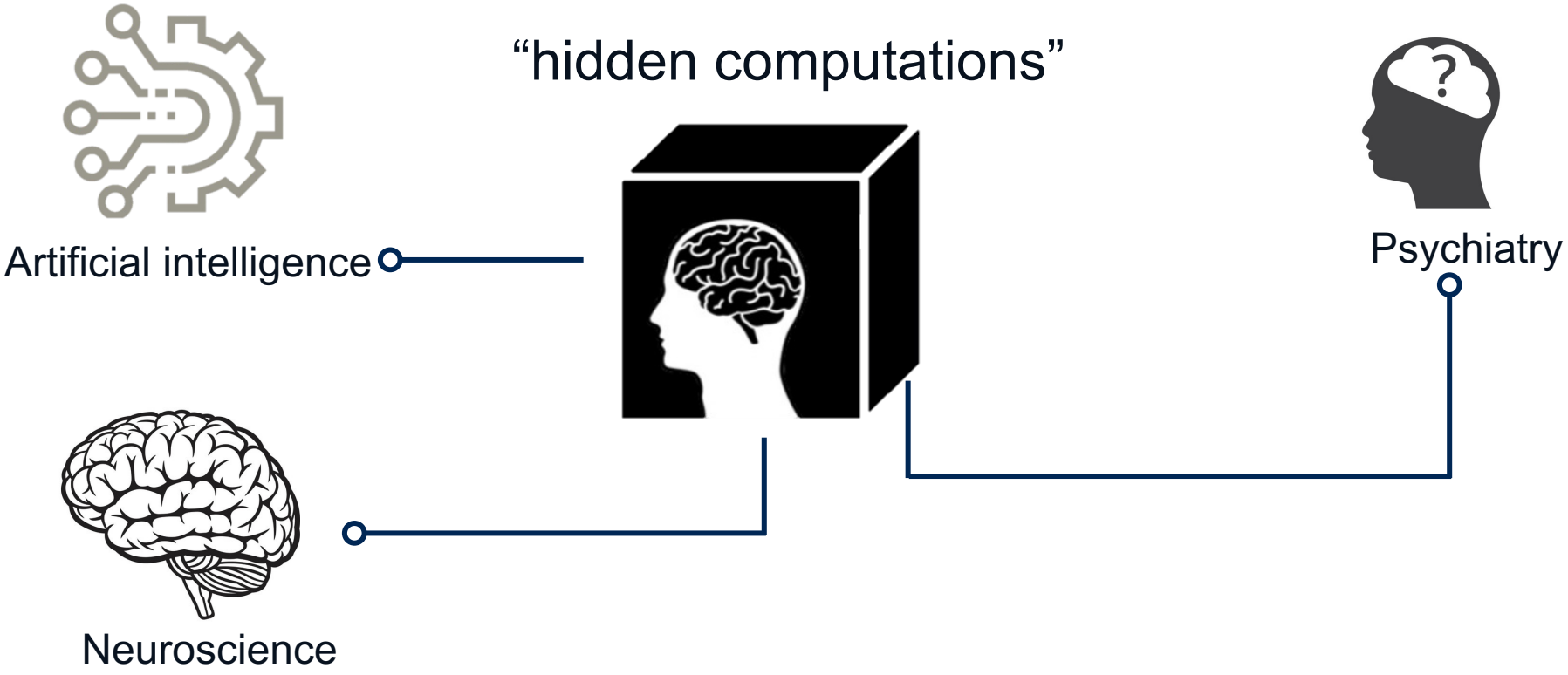
"Computational psychiatry applies computational modeling and theoretical approaches to psychiatric questions, focusing on building mathematical models of neural or cognitive phenomena relevant to psychiatric diseases."

"Computational psychiatry seeks to explain how psychiatric dysfunction may emerge **mechanistically,** and how it may be classified, predicted, and clinically addressed. It has the potential to bridge advances in neuroscience and clinical applications, connecting low-level biological features with high-level cognitive features"

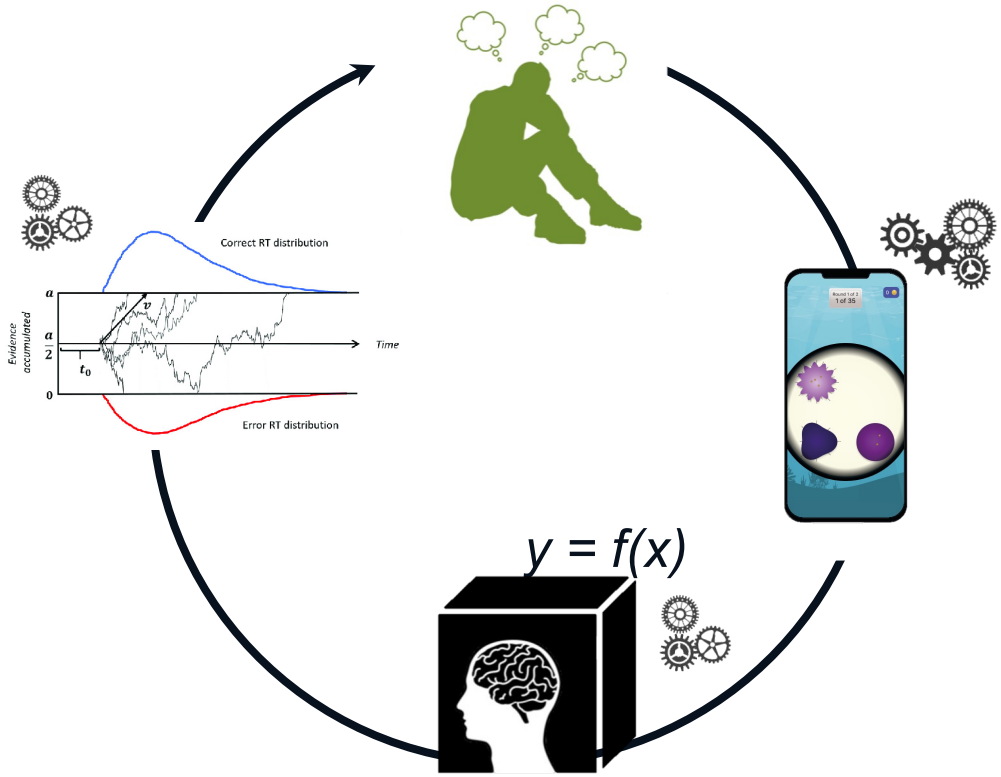
Core principles and aims of Computational Psychiatry

1. **Mechanistic Understanding:** Goes beyond surface symptoms to investigate the underlying neural, cognitive, and computational mechanisms of mental illness.
2. **Personalized Psychiatry:** Leverages computational models and individual patient data (e.g., brain imaging, genetics, behavior) to tailor diagnosis and treatment to each person's unique profile.
3. **Dimensional Approach:** Views mental disorders as existing on a spectrum rather than as discrete categories, allowing for more nuanced assessment and targeted interventions.
4. **Data-Driven Discovery:** Employs advanced computational tools and machine learning algorithms to analyze large-scale datasets, uncovering novel biomarkers and treatment targets.

Core principles and aims of Computational Psychiatry



Core principles and aims of Computational Psychiatry



Symptoms

Cognition

vs.

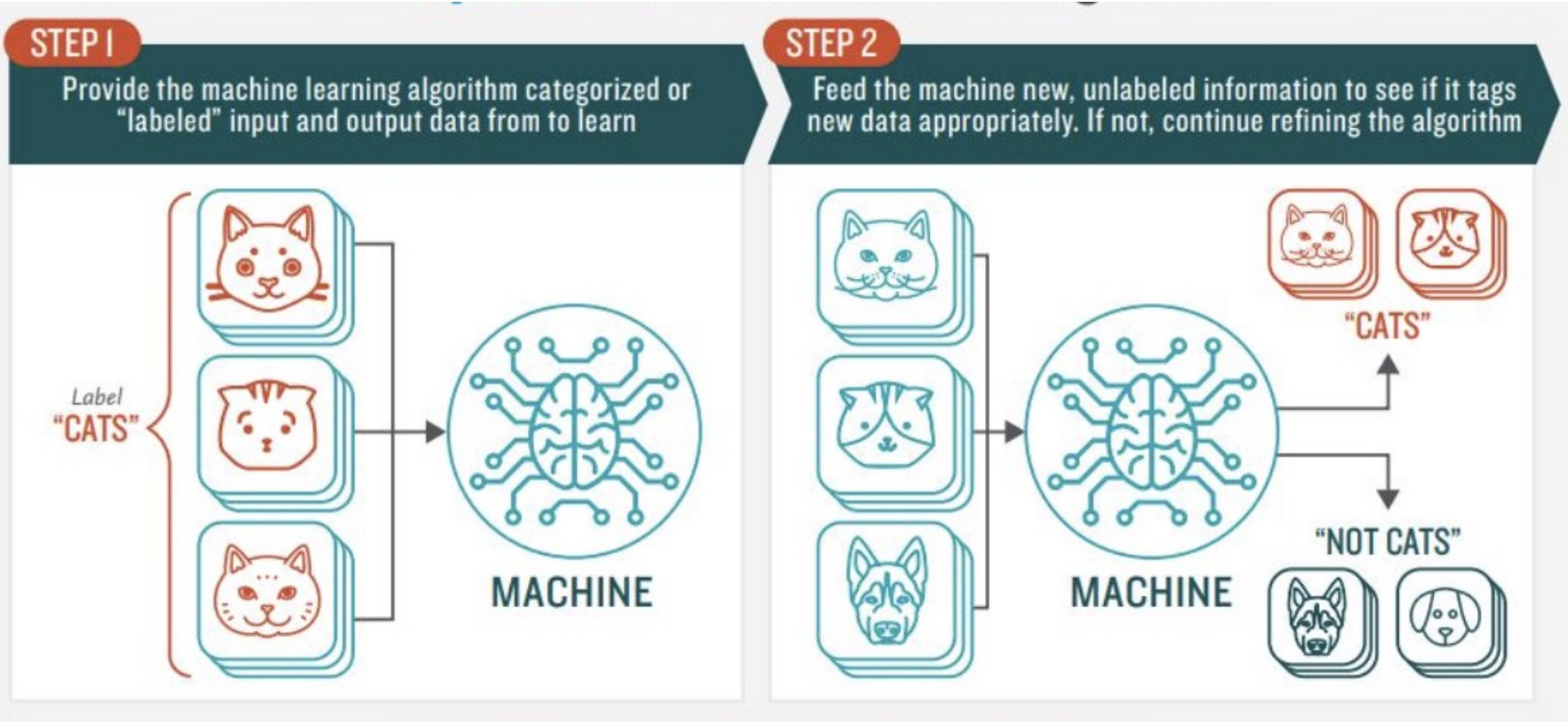
Brain

Loosen & Hauser, 2020

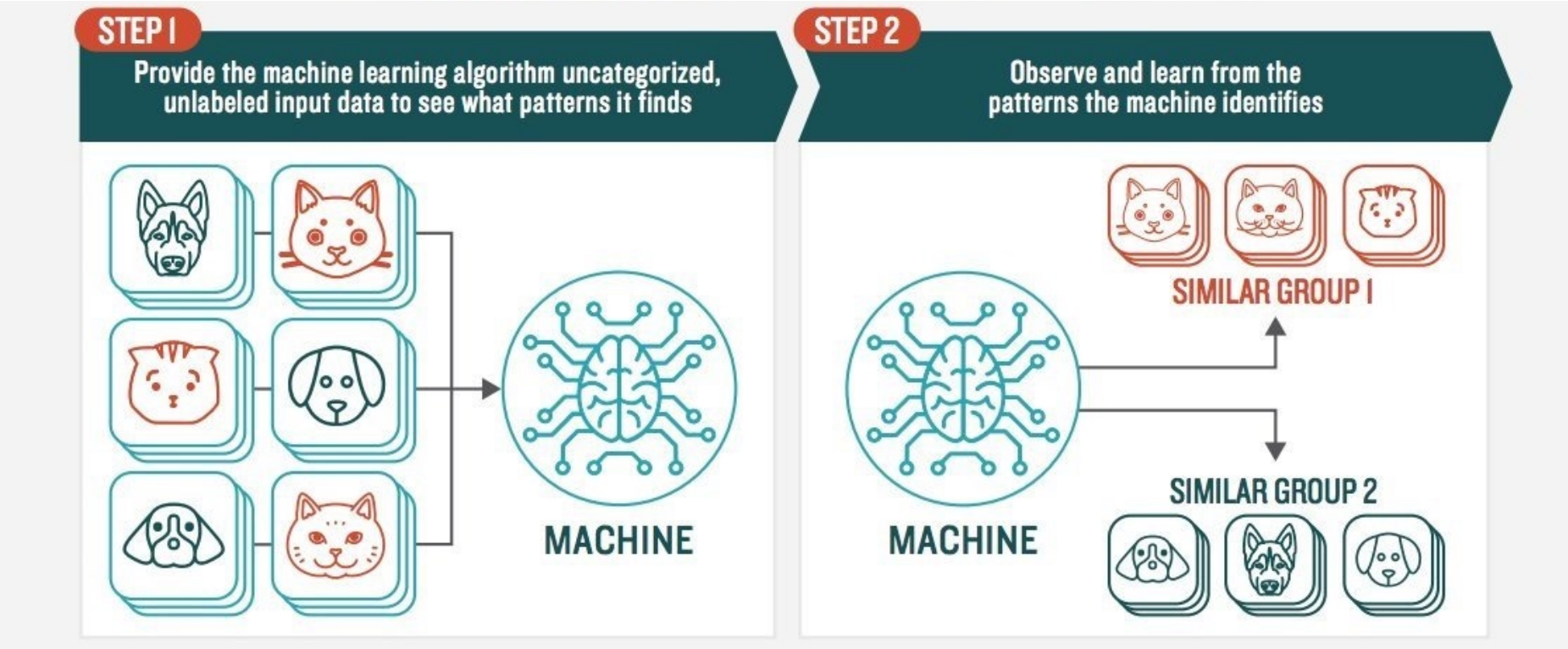
Two types of research

1. Data driven, “bottom up” approach
    - “Big data” approach
    - Machine learning to identify hidden structures in the data
        - Supervised and unsupervised learning
    - Example: Predicting treatment response in depression (Chekroud et. al., Lancet Psychiatry 2016)

Supervised learning



Unsupervised learning



Two types of research

1. Data-driven, “bottom up” approach
    - “Big data” approach
    - Machine learning to identify hidden structures in the data
        - Supervised and unsupervised learning
    - Predicting treatment response in depression (Chekroud et. al., Lancet Psychiatry 2016)

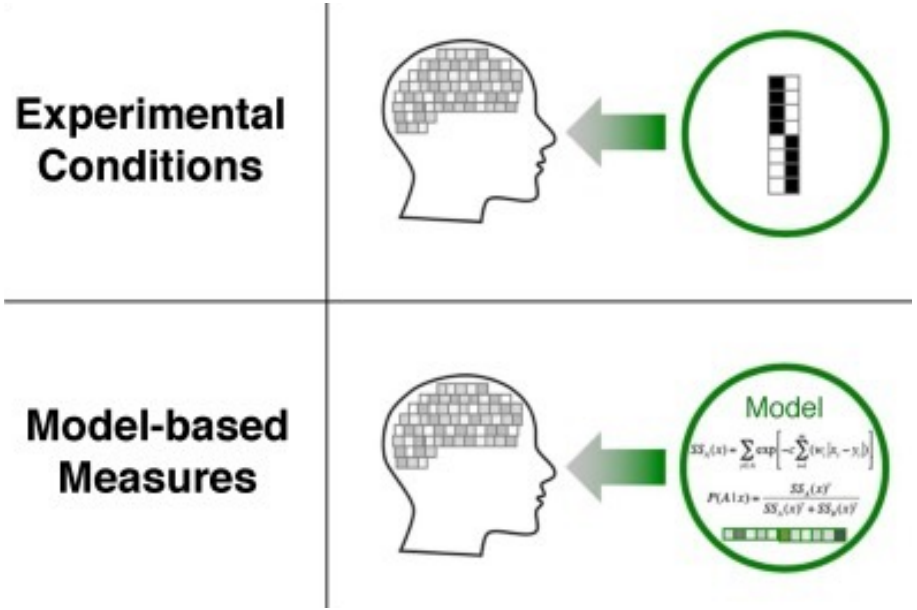
2. Theory-driven, “top-down” approach
    - Use existing knowledge to generate a theory, express that theory in mathematical terms
    - Computationally formalize how we learn based on observed neuronal activity (Schultz et. al., Science 1997)

How do we measure mechanisms?

- For instance:
  - altered decision-making is central to most psychiatric conditions
  - we can generate models of decision-making processes
  - altered learning is also central to many psychiatric disorders
  - can be measured with tools such as reinforcement learning (RL)

- Differences in the measured processes may give us insights about the disorder

Model-based fMRI



Thank you!

Any Questions?

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Next Class:

Tuesday 2nd of July

09:30am - 10:30am