frontiers in Psychiatry

Under the Hood: Using Computational Psychiatry to Make Psychological Therapies More Mechanism-Focused

Akshay Nair[1], Robb B. Rutledge[2,3] and Liam Mason[2,3,4] (2020)

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Psychotherapy

Background

Current Concern with Psychotherapy

Background

Part 1: How do existing treatments work? Making the case for the mechanisms of psychological treatments

Holmes et al. (2018)

Current Concern with Psychotherapy

Background

Consequences

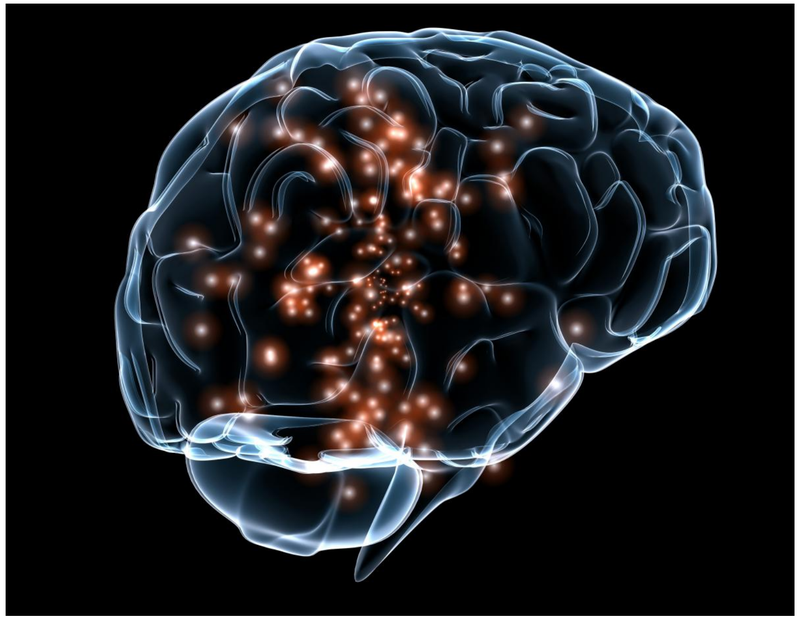
- Low efficacy of treatment
  - Only 45% of depressive patients have responded to CBT* (Queirazza et al., 2019).

**CBT: Cognitive Behavioral Therapy*

Growing Interest in Reducing the Gap between…

Background

Basic Science



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Clinical Research

Computational Psychiatry as a Solution

Introduction

Computational psychiatry as a bridge from neuroscience to clinical applications

Huys et al. (2016)

Computational Psychiatry as a Solution

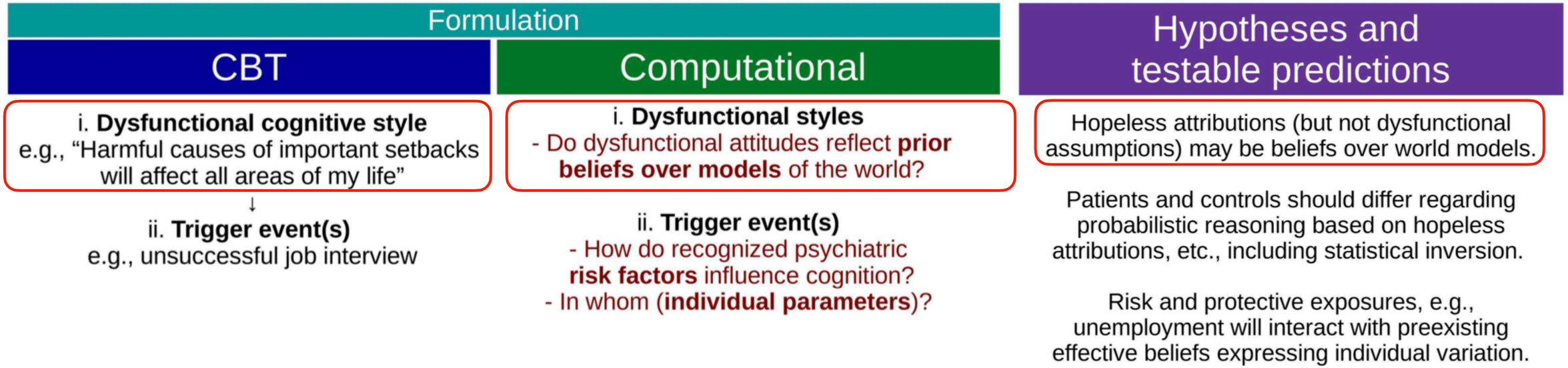
Introduction

“Theoretical framework for moving between higher-level psychological states to neural circuits, by modeling these constructs mathematically”

Nair et al. (2020)

“Computation in Psychotherapy”?

Introduction



Moutoussis et al. (2017)

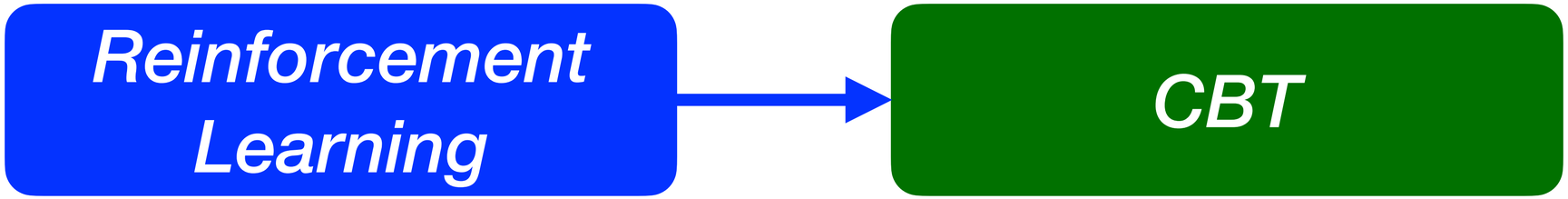
CBT and Computational Psychiatry

Introduction

? CBT and Learning?

- “CBT puts general learning and inference at the center of therapy (Moutoussis et al., 2017)”

Research Focus



CBT and Computational Psychiatry

Introduction

? What are the Goals of CBT?

- To change maladaptive cognitions, leading to changes in emotional distress and problematic behaviors (Hofmann et al., 2012)

- By using a combination of cognitive, behavioral, and emotional-focused techniques

Main Content

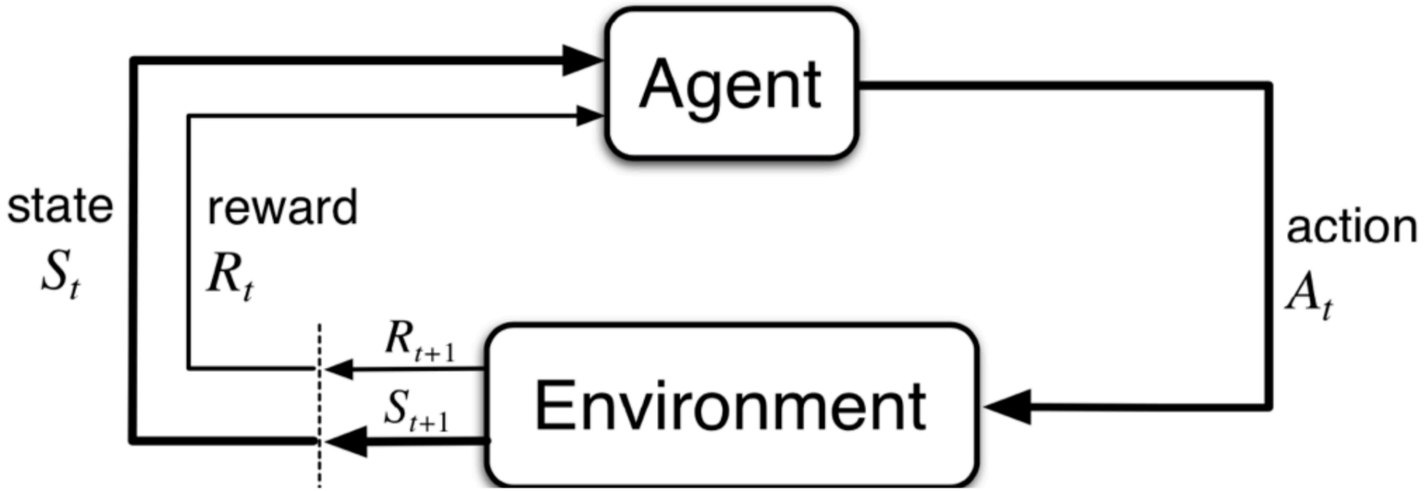
CBT and Reinforcement Learning

1. CBT in Computational Terms
2. Computational Parameters to Track Change during Psychotherapy
3. Application of Computational Parameters to Formulating and Tailoring Psychotherapy

Computational Description of CBT

CBT for Changing the Policy

- CBT is to “alter the mapping between *states* and *actions*, which is the *policy*”
- CBT is to “help patients adopt *new policies*”



Sutton & Barto (1998)

Computational Description of CBT

Prediction Error and Learning Rate to Change the Policy

Prediction Error?

= Actual reward - expected value of the action

Learning Rate?

: governs how fast the recent prediction error updates the action value

Computational Description of CBT

Real Problem to Computational Problem

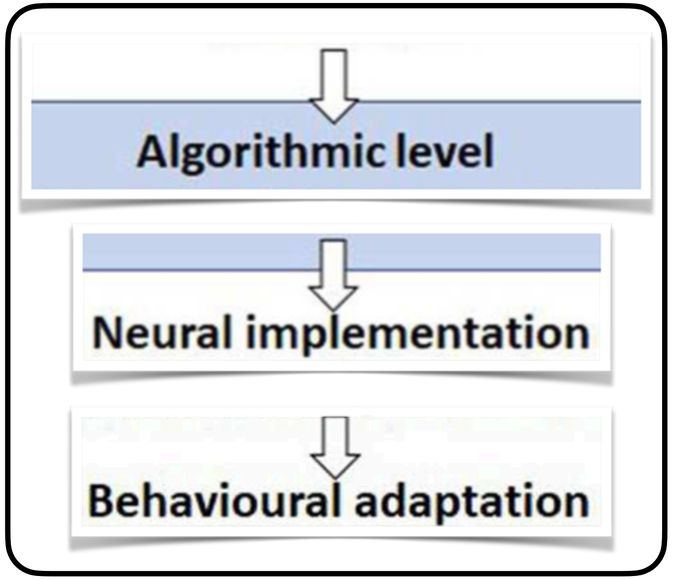
Real world problem:
I didn't enjoy that as much as I thought, should I do it again?

⇨

Computational problem:
One of these symbols will give you a reward more often than the other. Choose one.

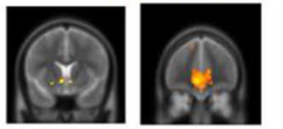
Implications for therapy

Failure to adapt behavior may be due to differences in learning rates or lack of attention to prediction errors.



$$\delta(t) = R(t) - Q_a(t)$$

$$Q_a(t+1) = Q_a(t) + \alpha * \delta(t)$$



$\delta(t)$ tracked in Ventral striatum

$Q_a(t)$ tracked in prefrontal cortex

Nair et al. (2020)

Computational Parameters in Psychotherapy

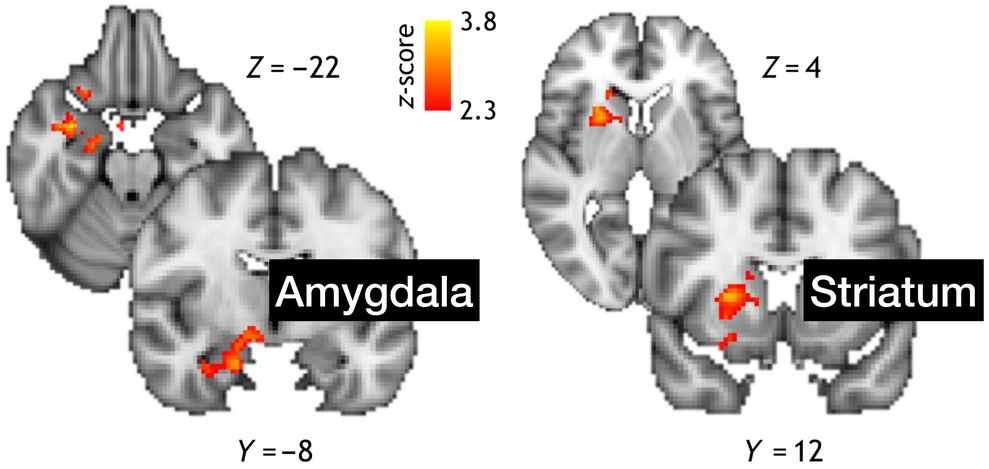
1)Prediction and 2)Change Tracking

- **I. *Learning rate* parameter values can be early predictors of treatment response.**
    - *e.g., behavioral experiment to try previously avoided actions*

Computational Parameters in Psychotherapy

1)Prediction and 2)Change Tracking

- **II. Neural encoding of prediction error can predict response to CBT.**
  - *e.g., the pretreatment neural correlates of reward prediction errors were associated with computerized CBT responses (Queirazza et al., 2019).*



CBT Responders > Non-responders
(pretreatment)

Computational Parameters in Psychotherapy

1)Prediction and 2)Change Tracking

- **III. *Learning rate* parameter values can track change during psychotherapy.**
    - *e.g., anxious patients showed higher punishment learning rate before treatment (Aylward et al., 2019)*

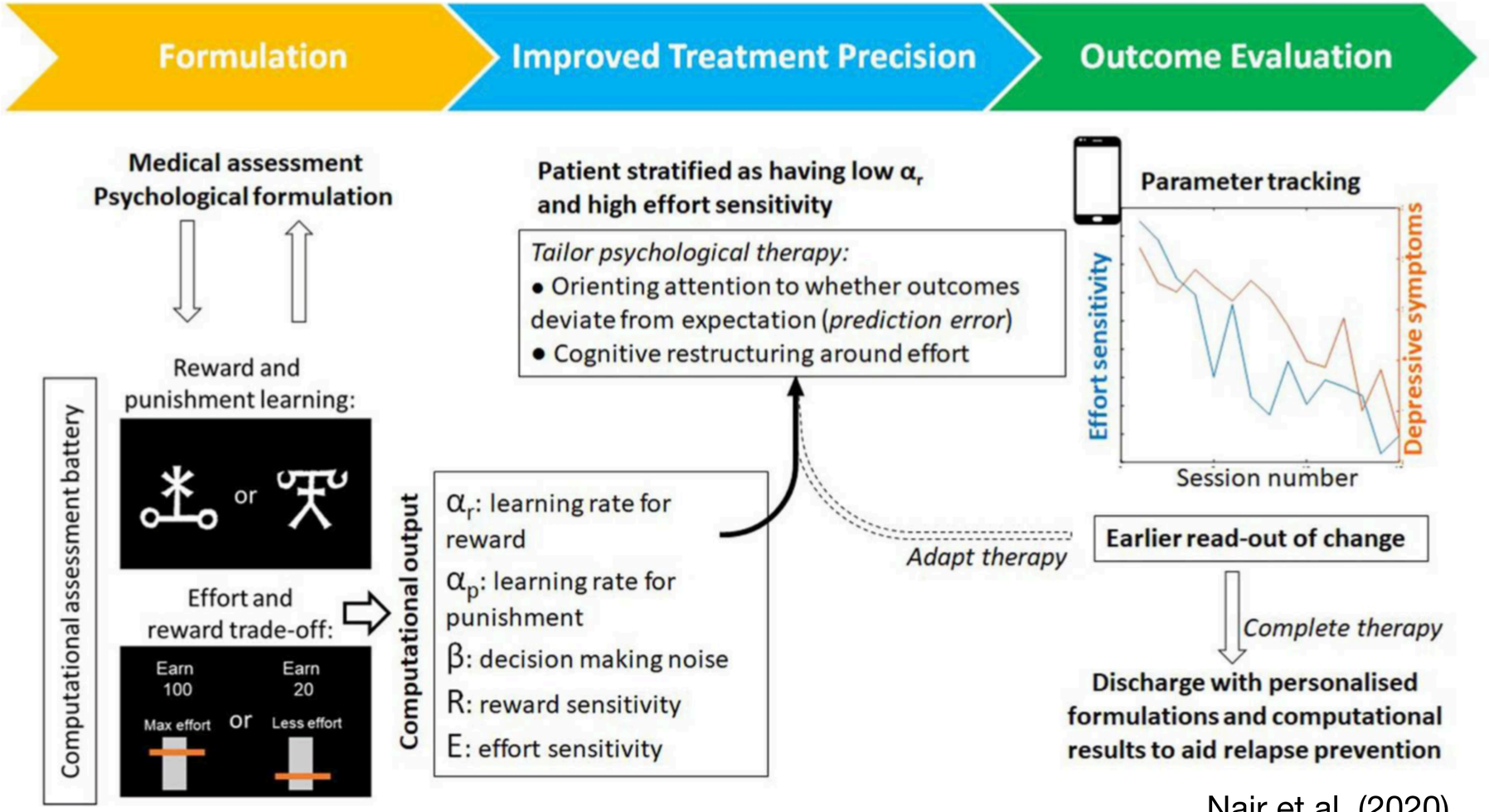
Formulating Psychotherapy

To Improve the Efficacy of Psychotherapy

1. **Individual variance in learning rate**
    - *e.g., change techniques might not be effective to patients with lower learning rates for that target belief*
2. **Targeted approach to increase learning rate**
3. **Preparatory work to promote attention to prediction errors**

Tailoring Psychotherapy

Patient Stratification with Computational Parameters



Nair et al. (2020)

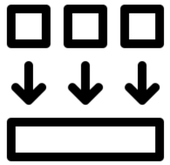
Advantages of using Computational Psychiatry

Conclusion

1. **Quantifiable and testable** 
2. **Potential markers of recovery** 
3. **Cheap and scalable** 

Key Hurdles

Conclusion

1. **Test-retest Reliability** 
    - *Stable task performance and parameter estimation*
    - *Structured tasks*
2. **Generalizability** 
    - *Ecological tasks*
    - *Parameters that reflect learning and decision-making in the real-life settings*

Thank you for listening!

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