Session No. I

Developmental
Computational
Psychiatry lab

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What is Computational Model(l)ing?

"All models are wrong, but some are useful"
George E. P. Box

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What we will cover:

- → Brief *introduction* to computational modelling
- → *Development* of a computational model
- → Principles of *model fitting*
- → Model *comparison, selection and validation*

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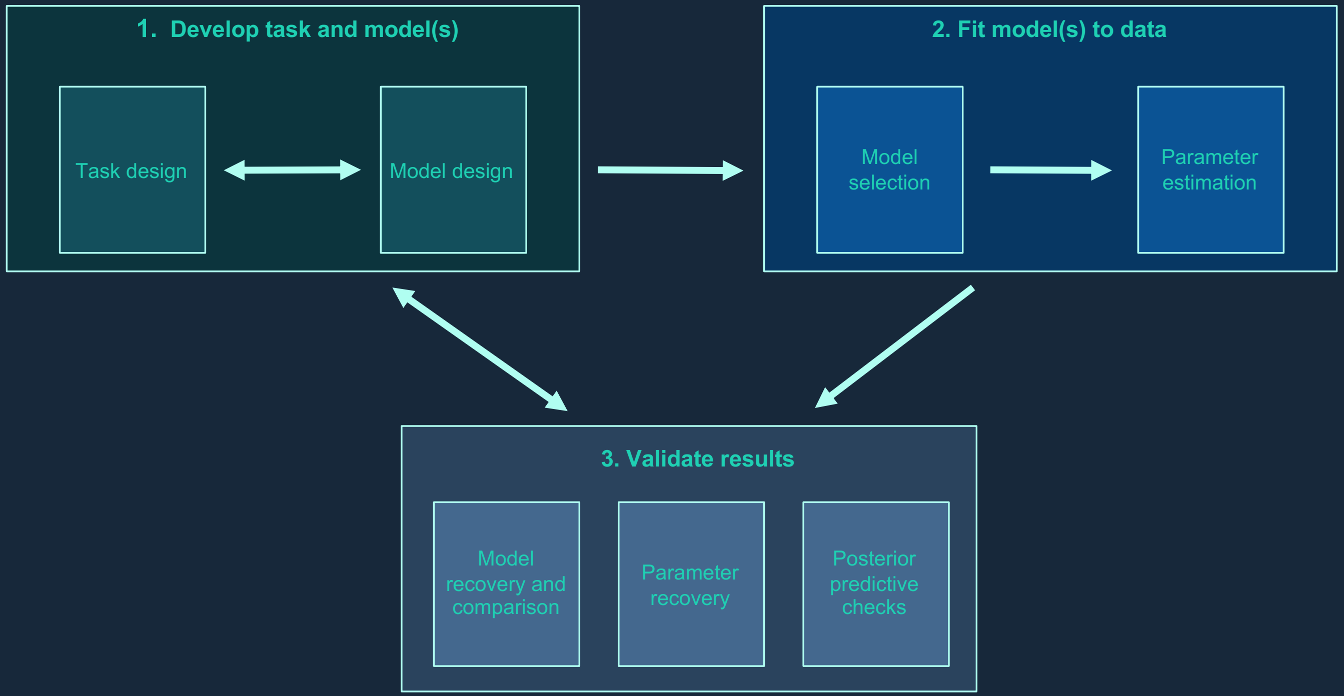
Framework:



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What we will cover:

→ Brief *introduction* to computational models
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→ Principles of ***model fitting***
→ Model ***comparison, selection and validation***

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Brief Introduction

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What we will cover:

- Why and for what data do we use computational models?
- Principles of computational modelling introduced by General Linear Models (GLMs)
  - Model fitting
  - Model complexity
  - Model comparison

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Computational models help us make sense of

Behavioural data (e.g., decision-making, learning)

Eye-tracking data

Neuroimaging data …

e.g., Hong et al., 2008; Hartley & Somerville, 2015; Hauser et al., 2019; Nour et al., 2021

They help us capture differences linked to

Psychiatric conditions

Developmental stages …

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1. Develop task and model(s)

Task design ⟷ Model design

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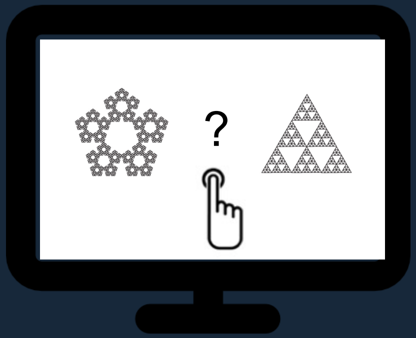
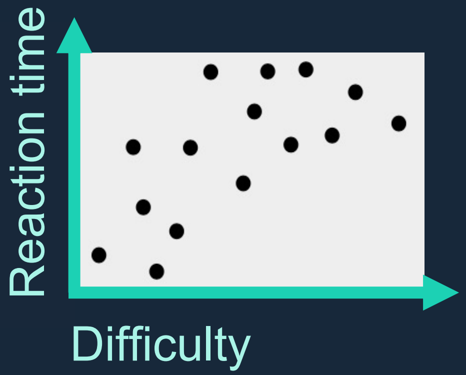
Input



Cognitive processes

Output



"hidden computations"

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"hidden computations"

Observed data =
intercept + (slope * predictor) + *residuals*

$$y = b_0 + b_1 x + e$$

Some math happens

$$y = f(x)$$

reaction time   *difficulty*

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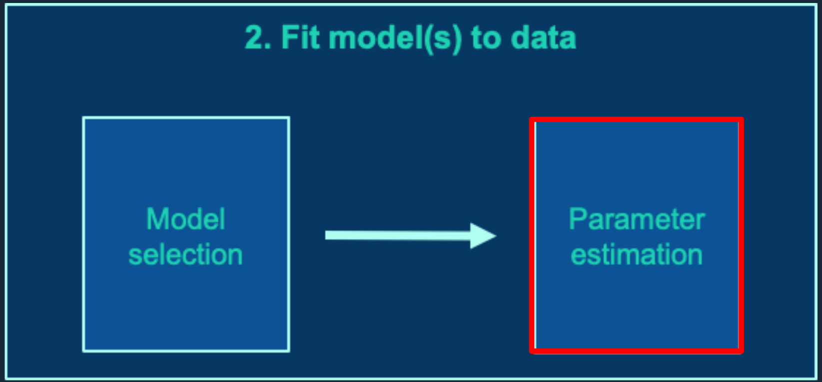

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Model fit: parameter estimation

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Observed data =
intercept + (slope * predictor) + *residuals*

Reaction time =
$b_0 + b_1$difficulty+e

Free parameters

Model fit:
try to estimate the values of (free) parameters that best describe data

Techniques:
Least Square Approach: find parameter estimate that minimizes the sum of square of residuals (i.e., unexplained variance)

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Model fit: parameter estimation

Observed data =
intercept + (slope * predictor) + *residuals*

Reaction time =
$b_0 + b_1 difficulty + e$

Free parameters

Example:

$\boldsymbol{y} = b_0 + b_1 difficulty + e$

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Model fit: parameter estimation

Observed data =
intercept + (slope * predictor) + *residuals*

Reaction time =
$b_0 + b_1 difficultty + e$

Free parameters

Example:

LQM: minimize distance

$y = b_0 + b_1 difficulty + e$

Least Square Method:
minimizes sum of square residuals: vertical lines between data points and fitted line.

Regression coefficient:
reflects the steepness and sign of the fitted slope

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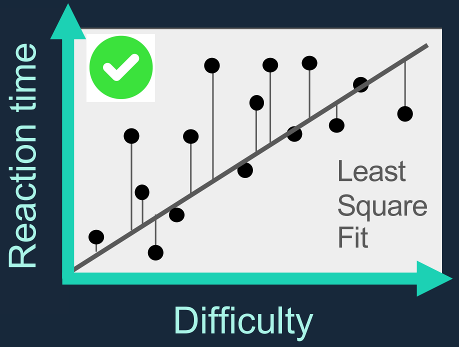
Model fit: parameter estimation

Observed data =
intercept + (slope * predictor) + *residuals*

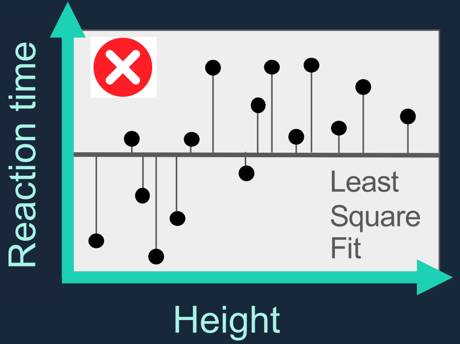
Reaction time =
$b_0 + b_1 difficulty + e$

Free parameters

Example:



$y = b_0 + 1.5x difficulty + e$



$y = b_0 + 0x height + e$

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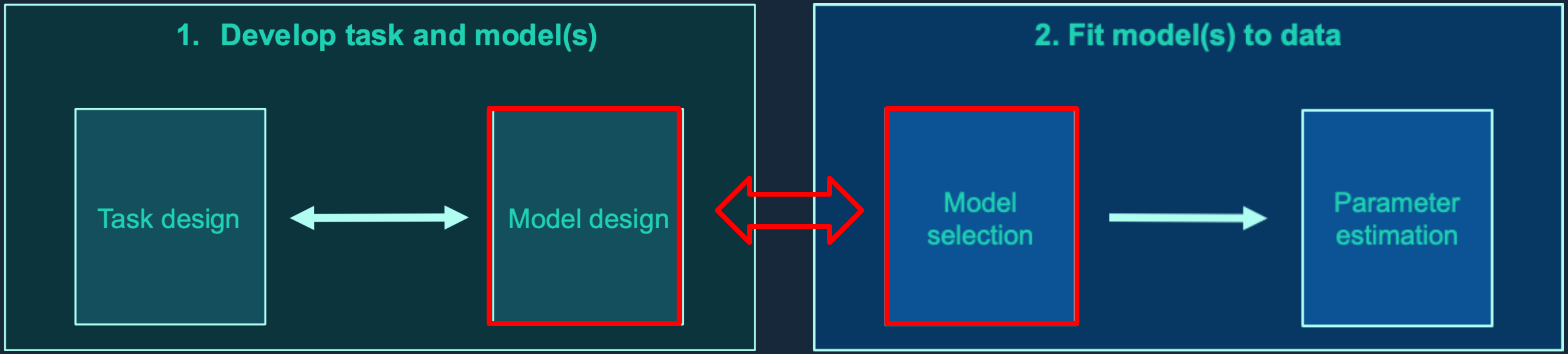

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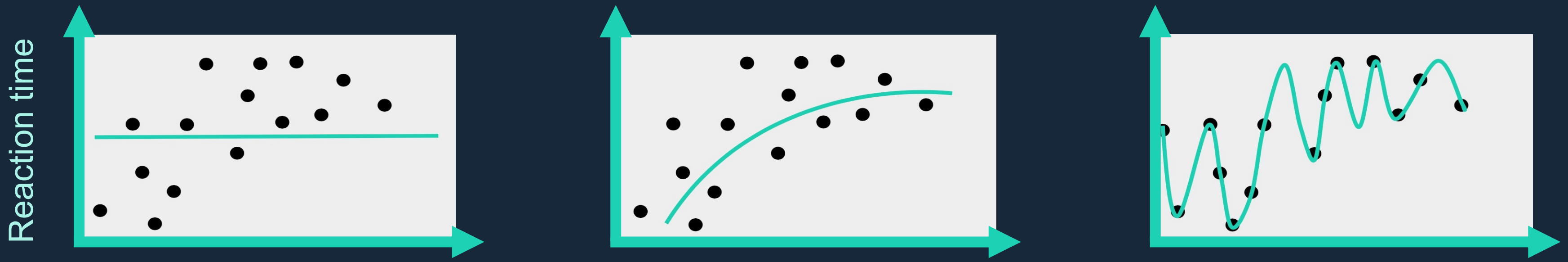
Model complexity



$y = b_0 + e$

$y = b_0 + b_1 * difficulty + b_2 * time\ pressure + e$

$y = b_0 + b_1 x^1 + b_2 x^2 + \ldots + b_6 x^6 + e$

- Temperature
- Daytime
- …

Adapted from Bonifay (2021)

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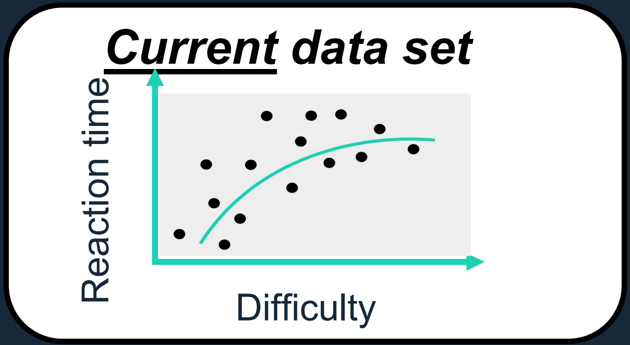
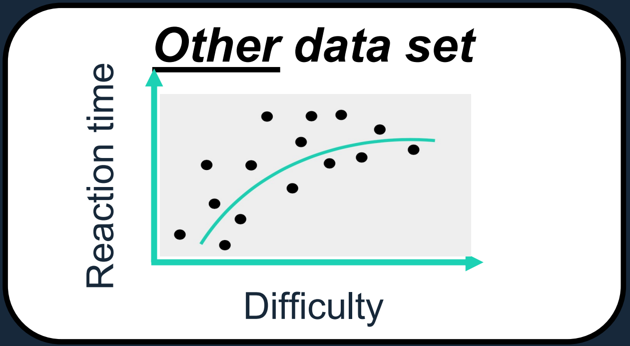
Model complexity





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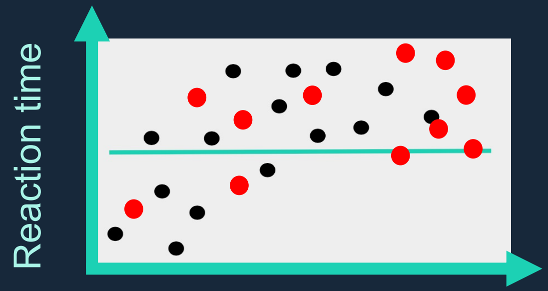
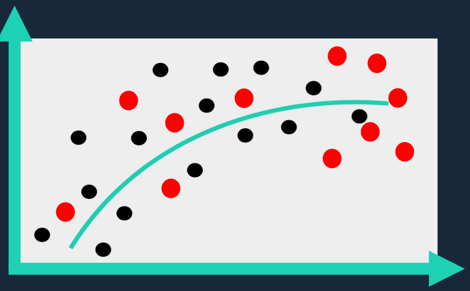
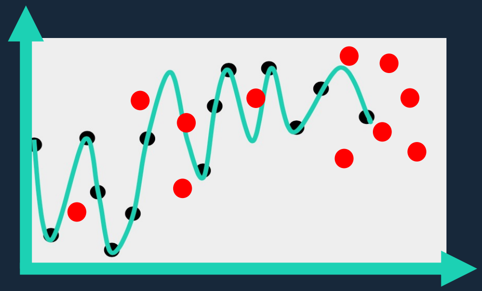
Model complexity







Underfitting

$y = b_0 + e$

Robust

$y = b_0 + b_1 * difficulty + b_2 * time\ pressure + e$

Overfitting

$y = b_0 + b_1 x^1 + b_2 x^2 + \ldots + b_6 x^6 + e$

- Temperature
- Daytime
- …

Adapted from Bonifay (2021)

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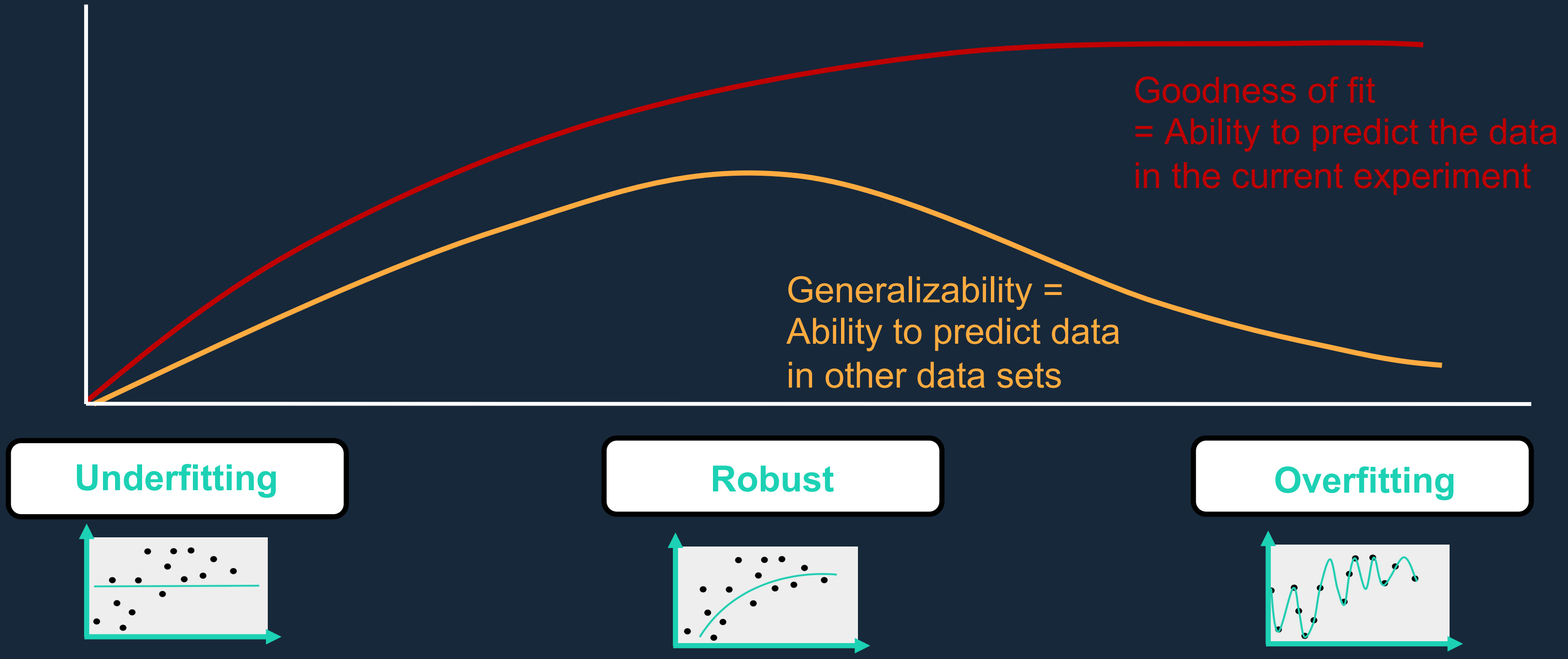
Model complexity



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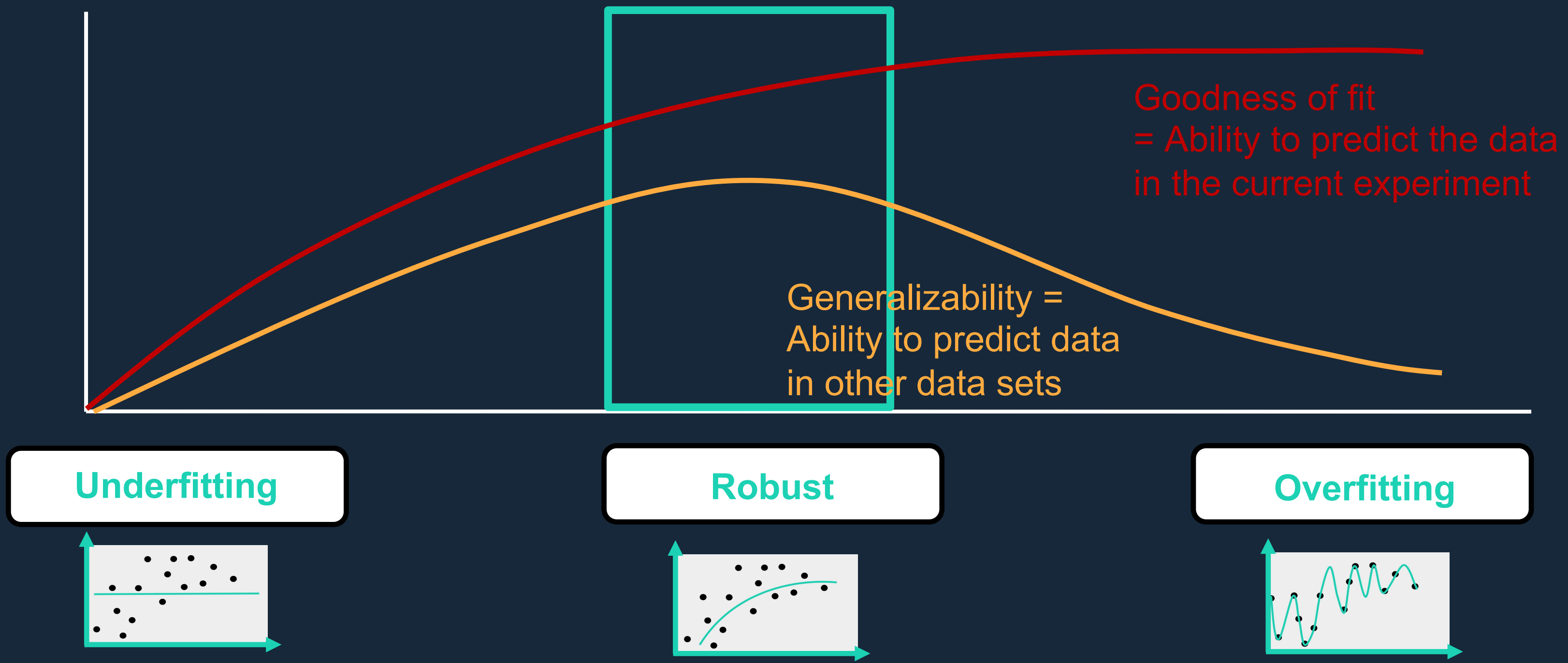
Model complexity



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3. Validate results

- Model recovery and comparison
- Parameter recovery
- Posterior predictive checks

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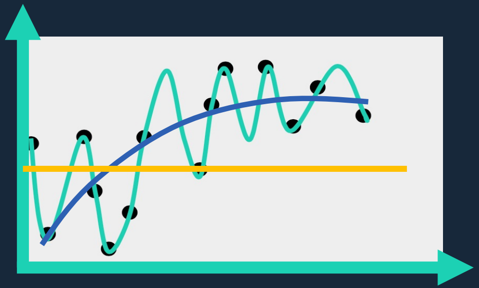
Model comparison

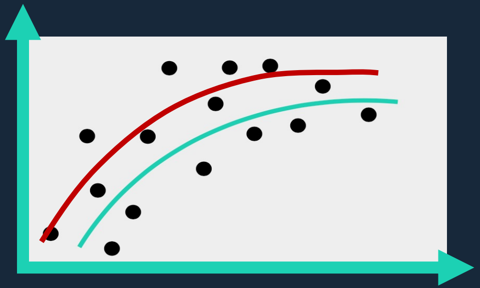


Model comparison:
Which model, out of a set of possible models, is most likely to have generated the data.

Underfitted model
Robust model
Overfitted model

Adapted from Bonifay(2021)

Model comparison



$y = b_0 + b_1 \textit{difficulty} + e$

$y = b_0 + b_1 \textit{time pressure} + e$

Model comparison:
Which model, out of a set of possible models, is most likely to have generated the data.

Techniques:
Bayesian Information Criterion (BIC)
Akaike Information Criterion (AIC)

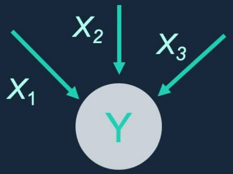
Adapted from Bonifay(2021)

GLM vs. computational models

GLMs

→ requires explicit formulation of task variables

→ receives one or more parallel direct inputs

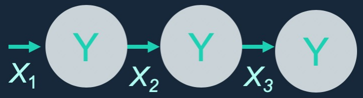


Parallel input

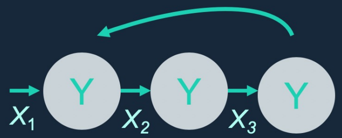
Computational model

→ Can infer latent (hidden) processes (e.g., beliefs,…)

→ Predict data of nonlinear systems, that involve series pathways, feedback processes etc.



Serial input



Feedback

Adapted from Mujica-Parodi & Strey (2020)

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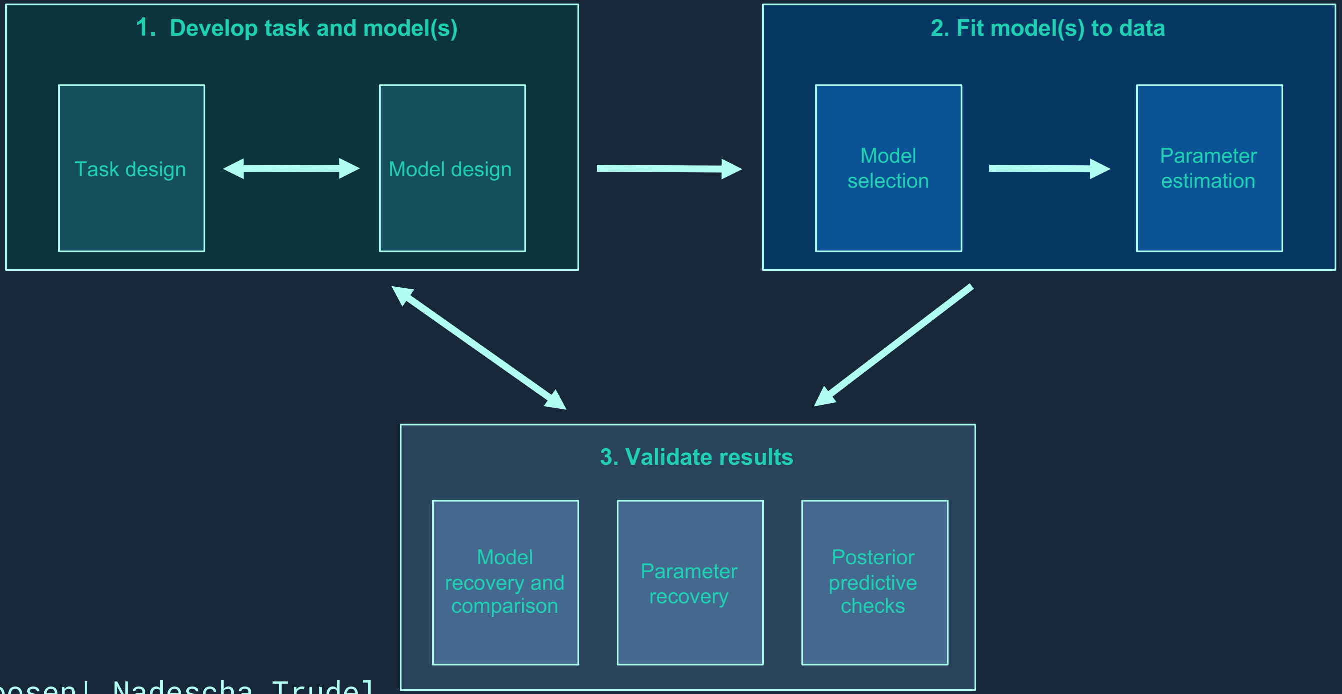
Overview



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