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Predicting Real-Life Self-Control From Brain Activity Encoding the Value of Anticipated Future Outcomes

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Jihyun Hur

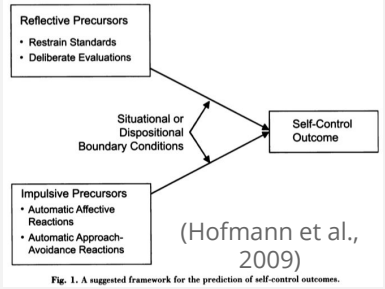
The Psychology of Emotional, Behavioral, and Motivational Self-Regulation

Self-Control Theories

Dr. Roy Baumeister

https://www.cobizmag.com/5-methods-to-enhance-your-brain-for-greater-productivity/

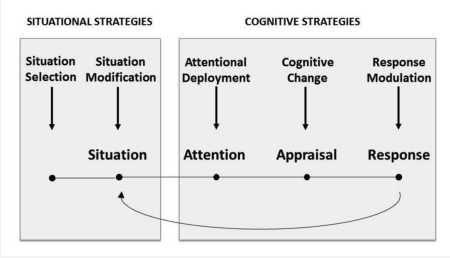
Dr. Wilhelm Hofmann



(Hofmann et al., 2009)

Fig. 1. A suggested framework for the prediction of self-control outcomes.

Dr. Angela Duckworth



(Duckworth et al., 2016)

“Self-Control as a Value-Based Choice” (Berkman et al., 2017)

Dr. Elliot Berkman

“There is nothing unique about self-control. Instead, decisions that we label self-control are merely ***a fuzzy subset of all value-based decisions…”***

Value-Based Decision-Making

$$SV = \sum_i w_i \, Attribute_i.$$

(SV: subjective value)

Background

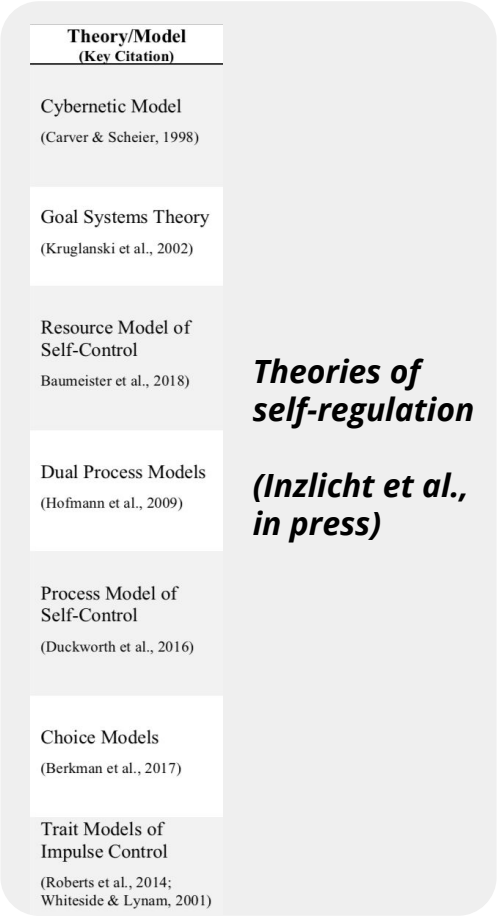
1 *Self-control theories*

- **Strength model** (Baumeister et al., 2007)
- **Dual-system Model** (Hofmann et al., 2009)
- **Process Model** (Duckworth et al., 2016)
- **Choice Model** (Berkman et al., 2017; Krönke et al., 2020)

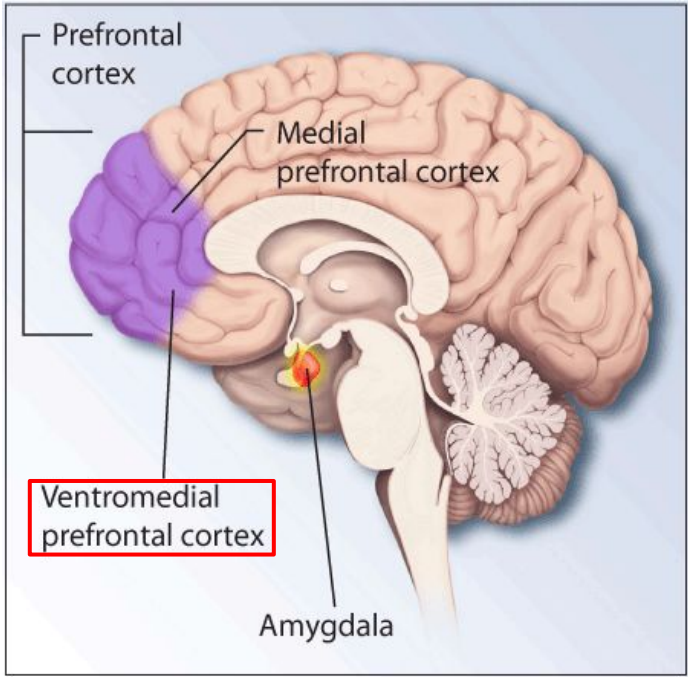
2 *Ecological validity of lab tasks*

- *Integration of behavioral measures and neural activation*
- ***Brain-as-predictor***

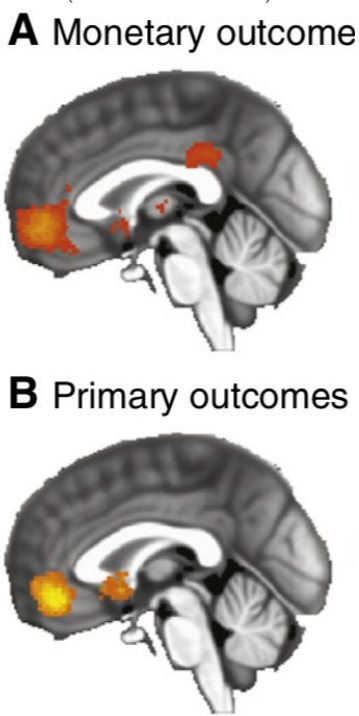
3 *Role of ventromedial prefrontal cortex (vmPFC)*



vmPFC and Hypotheses



(Bartra et al. 2013)



- Encodes the subjective value of…
  - Primary (food) reward
  - Monetary reward
  - Social reinforcers
- Q1: Would it also encode the **subjective value of daily behaviors?**
- Q2: How would it be related to **real-life self-control failures?**

Authors

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- Postdoc at Technische Universität (TU) Dresden
- Self-control, fMRI

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- Postdoc at TU Dresden
- Self-control, stress, addiction

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- Cognitive control, affect

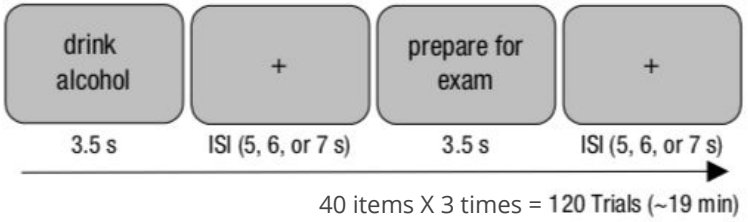
Method I: fMRI

Participants

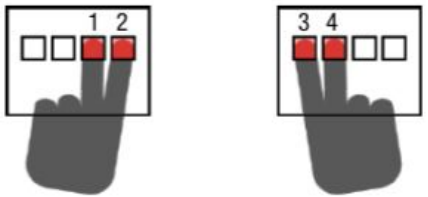
- 194 young adults (225 in total)
- Exclusion:
  - Neurological conditions
  - Psychiatric disorders
  - Eligibility for MRI

fMRI Session

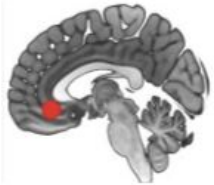
Value-based Decision-Making Task



40 items X 3 times = 120 Trials (~19 min)



Strong Yes (1), *Yes* (2), *No* (3), *Strong No* (4)



8-mm Sphere
($x = 3$, $y = 35$, $z = -11$)

Post-fMRI

Questionnaire

"Rate the consequences of these activities (e.g. drink alcohol) from **very positive to very negative.**" (short-term, long-term)

Method II: Self-Reported Measures

Daily reports

Trait report

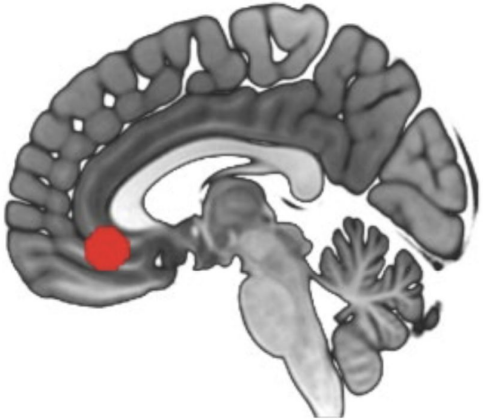
Brief Self-Control Scale (BSCS)

- 13 items
- High scores = high levels of trait self-control

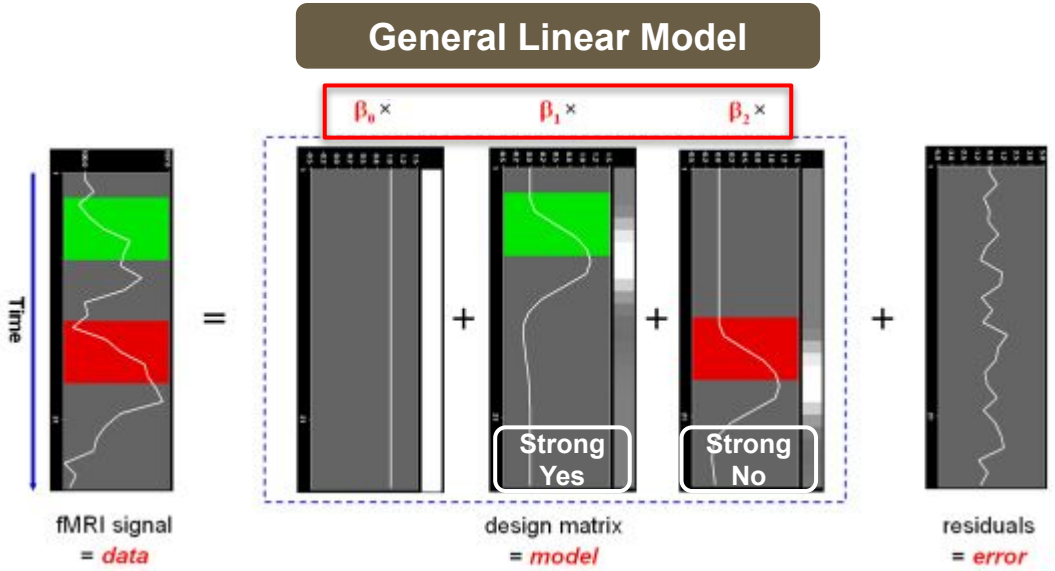
Q1: vmPFC & Value of Daily Activities

To answer this question...

Region of Interest: **vmPFC**



8-mm Sphere
($x = 3$, $y = 35$, $z = -11$)



https://www.brainvoyager.com/bv/doc/UsersGuide/StatisticalAnalysis/TheGeneralLinearModel.html

Regressors

- GLM 1: decision trials + decision value
- GLM 2: decision trials + long-term consequences, short-term consequences, interaction

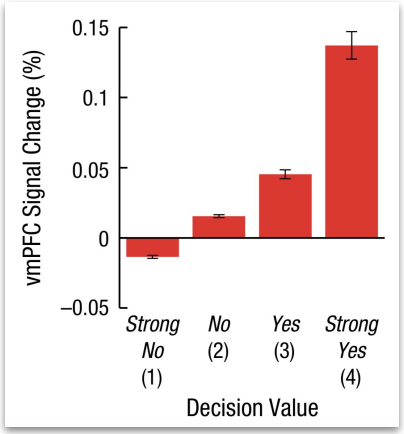
Q1: vmPFC & Value of Daily Activities

$$\text{percentage signal change} = \frac{\beta(\text{task}) \times \max(\text{HRF}) \times 100}{\beta(\text{constant})},$$

- To calculate the percent change of the signal in the peak voxel* compared to the baseline (or mean activation in the ROI) during the event

Result

- **vmPFC encoded the value of daily activities.**
- Even for **imagined** daily behaviors.



Voxel: unit of brain region*

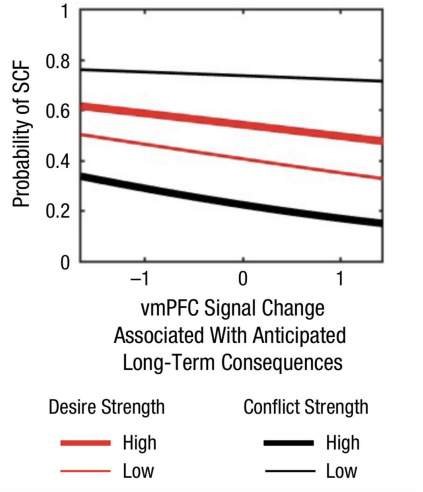
Q2: vmPFC & Real-life Self-Control Failures

Hierarchical Linear Model

- *Desire and conflict strength data (level 1) were nested within participants (level 2).*

Models → to predict the frequency of self-control failures

1. HLM1: **vmPFC by anticipated long-term and short-term consequences**
2. HLM2: HLM1 + BSCS scores



Results

- **Higher desire strength** and **lower conflict strength** were associated with **self-control failures.**
- **Increased percentage signal change in vmPFC modulated by the anticipated long-term consequences** was associated with **less self-control failures (but not for short-term).**
- This result remained **even after BSCS scores were included** in the model.

Discussion

- Lab tasks and neuroimaging data can elucidate the cognitive and neural mechanisms of real-life self-control behaviors.
- vmPFC reflects the subjective value of daily activities.
- Neural signal in vmPFC modulated by anticipated long-term consequences is significantly associated with individual differences in the probability of committing self-control failures (→ dynamic integration process).
- By utilizing neural data along with self-reported measures, we can better predict real-life outcomes and overcome the gap between lab measures and real-life behaviors.

Literature

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