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

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

Dr. Roy Baumeister

Dr. Wilhelm Hofmann

(Hofmann et al., 2009)

Dr. Angela Duckworth

(Duckworth et al., 2016)

https://www.cobizmag.com/5-methods-to-enhance-your-brain-for-greater-productivity/
“Self-Control as a Value-Based Choice” (Berkman et al., 2017)

“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**

\[ SV = \sum_i w_i \text{Attribute}_i. \]

(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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- 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

- drink alcohol
- prepare for exam

3.5 s ISI (5, 6, or 7 s) 3.5 s ISI (5, 6, or 7 s)

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

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

Measuring Real-Life Self-Control: Experience Sampling

56 Questionnaires on Smartphone in 7 Days to Assess
- Desire
- Desire Strength
- Conflict
- Conflict Strength
- Enactment

Self-Control Failure = Desire + Conflict + Enactment

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
\((x = 3, y = 35, z = -11)\)

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

Q1: vmPFC & Value of Daily Activities

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.
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.


