Decision-Making

SPICE 2024

Neuroscience & Computational Psychiatry Module

Class VII

Mount Sinai

Center for Computational Psychiatry

9th of July 2024

Decision-making

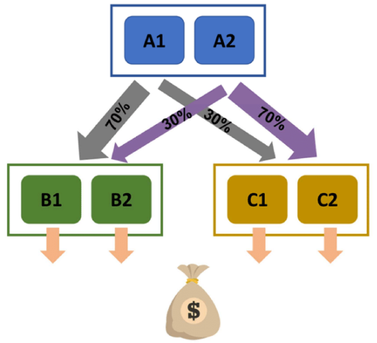
Cognitive process of selecting among alternatives.

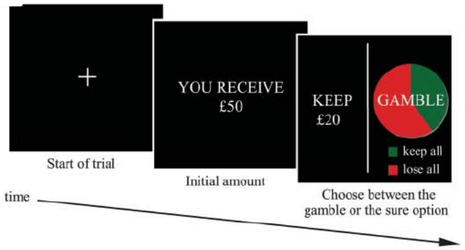
Types of Decision-Making:

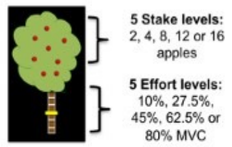
- **Reward-based:** Choices driven by expected rewards
- **Economic:** Choices involving trade-offs between costs and benefits
- **Effort-based**: Choices driven by expected effort associated with the options
- **Perceptual:** Choices based on sensory information
- **Social:** Choices influenced by others or made together with others

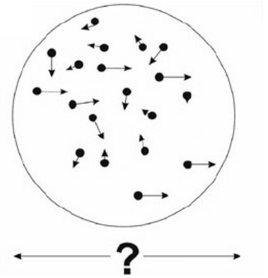
And many more..

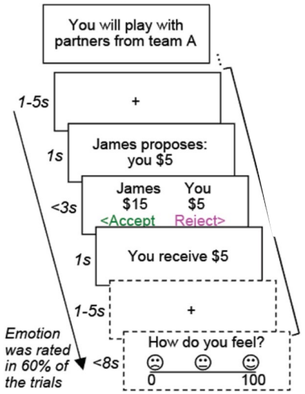
Often altered in psychiatric and neurological disorders.





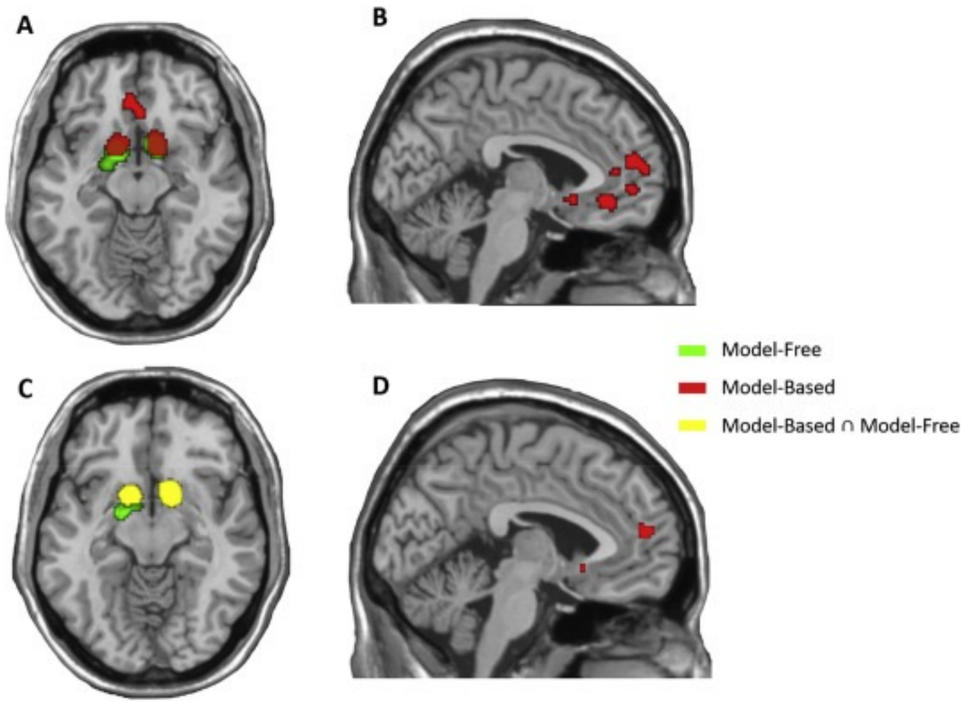






Reward (Value)-based decision making

- **Focus:** Driven by the anticipation and receipt of rewards and based on a value calculation.
- **Primary Motivator:** Pleasure, monetary gain, satisfaction, or relief etc.



Exemplar Neural Mechanisms:

- **Ventrolateral prefrontal lobe**
- **Orbitofrontal lobe**
- **Anterior cingulate cortex (ACC)**
- **Ventral striatum**
- **Mesolimbic dopaminergic system**

Image: Huang, Taple, & Yu, 2020

Paper discussion

Characterizing a psychiatric symptom dimension related to deficits in goal-directed control

Claire M Gillan ✉, Michal Kosinski, Robert Whelan, Elizabeth A Phelps, Nathaniel D Daw

New York University, United States; University of Cambridge, United Kingdom; Stanford University, United States; University College Dublin, Ireland; Nathan Kline Institute, United States; Princeton University, United States

1. **What are the main three research questions and how are they motivated?**
2. **What are the main methods?**
3. **What are the main findings?**
4. **What do these findings mean?**

Paper discussion

Main Research Questions:

1. Are deficits in goal-directed control specifically linked to OCD symptoms?
2. Do these deficits generalize to other compulsive disorders (symptoms) beyond OCD symptoms?
3. How specific is the association between goal-directed deficits and compulsive behavior compared to non-compulsive symptoms?

Methods:

- Participants: Two large general-population samples.
- Assessments: Reinforcement-learning task for goal-directed (model-based) learning & self-report questionnaires for various psychiatric symptoms.
- Analysis: Regression and factor analyses.

Main Findings:

1. Association between goal-directed control deficits and a dimension comprising compulsive behavior and intrusive thoughts.
2. Specificity of this association to compulsive symptoms, not extending to non-compulsive symptoms like depression or anxiety.
3. Compulsive dimension linked to OCD, addiction, and eating disorders.

Paper discussion

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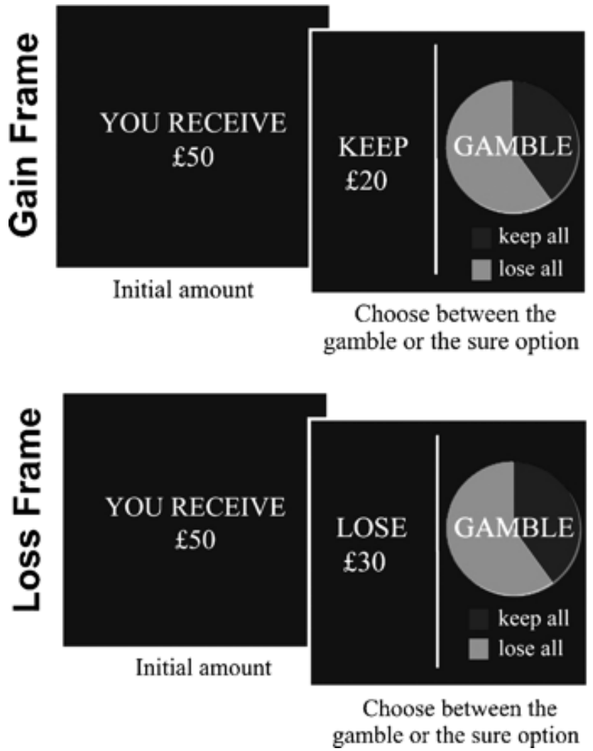
Criticism? What could have been improved?

Economic decision making

- **Focus**: Involves evaluating trade-offs between costs and benefits to maximize utility or value.
- **Primary Motivator**: Rationality and optimization of resources (form of *value-based decision making*).
- **Example**:

  Framing: humans are highly susceptible to the manner or context in which options are presented



Exemplar Neural Mechanisms:

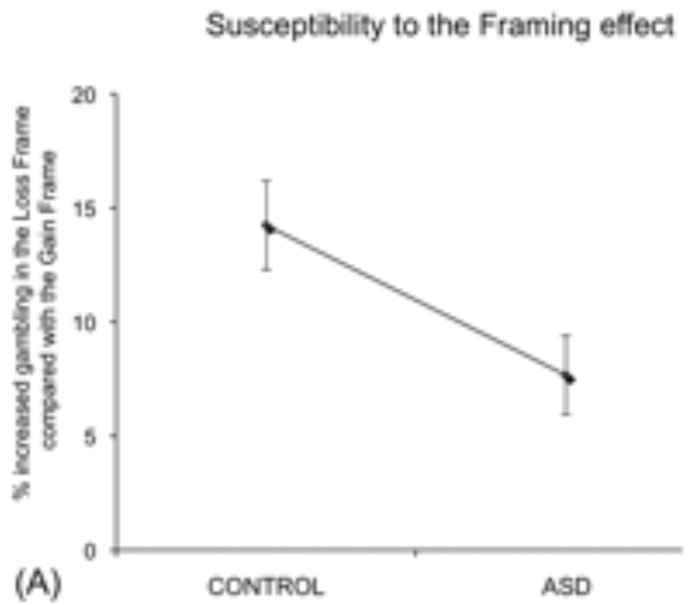
- **Prefrontal cortex (PFC)**
- **Anterior cingulate cortex (ACC)**
- **Striatum**
- **Amygdala**
- **Hippocampus**
- **Insula**

Example: Amygdala seems to be linked to the framing effect (loss aversion).

Image: De Martino et al., 2006, 2008

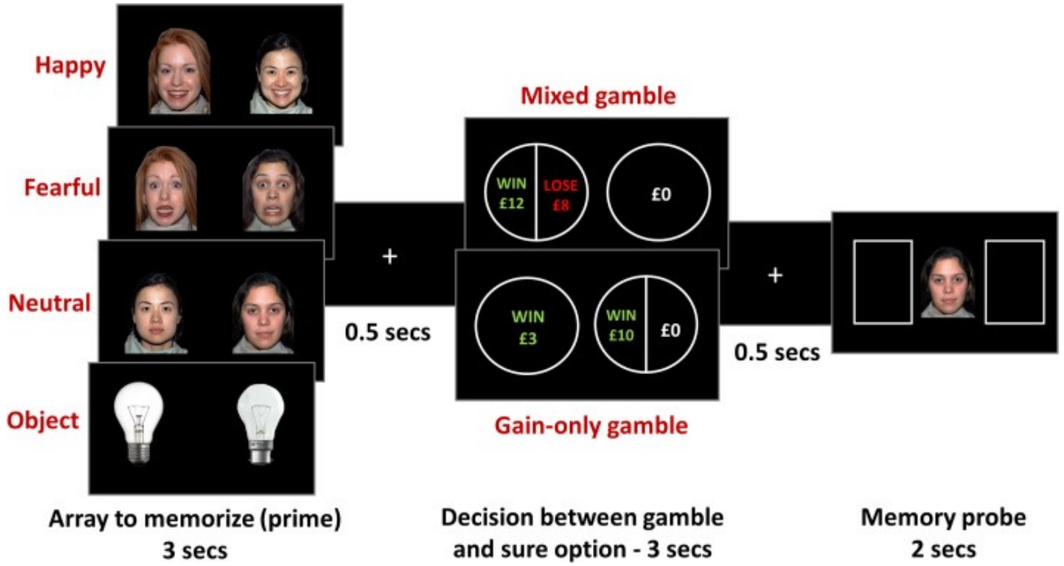
Alterations of economic decision making

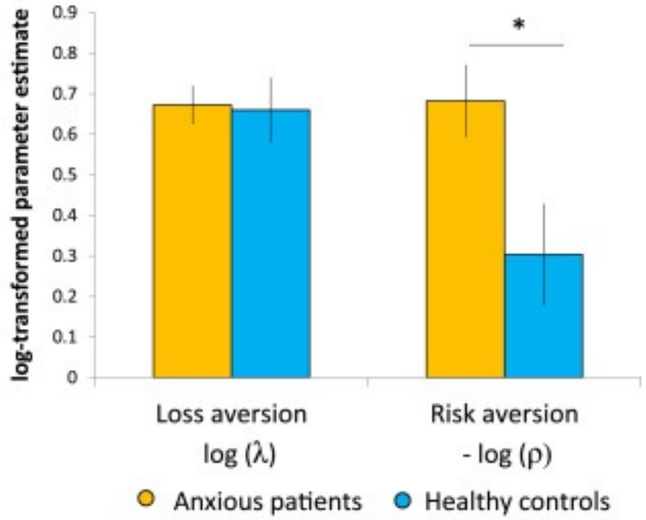
Autism spectrum disorder



De Martino et al., 2008

Anxiety



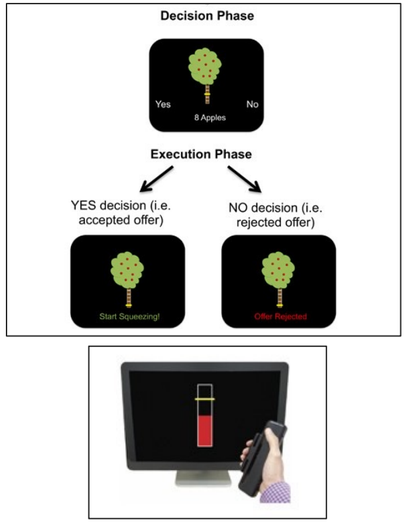


Charpentier et al., 2017

Effort-based decision making

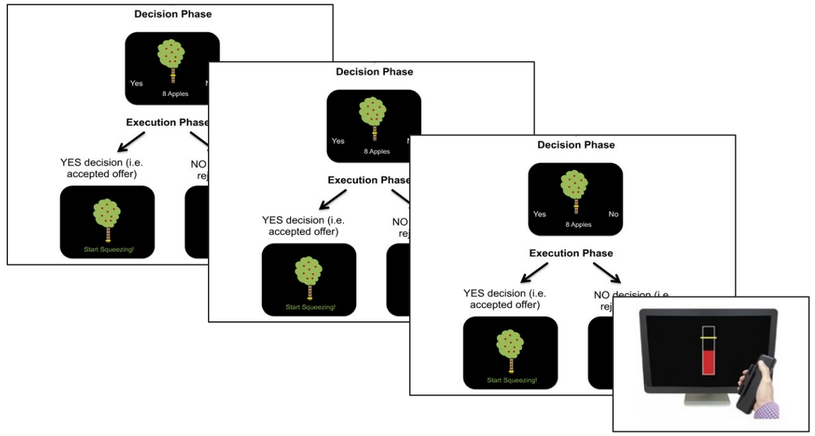
- **Focus**: Involves evaluating how much effort to invest in something or how much effort something desirable is worth.
- **Primary Motivator**: Trade-off between subjective reward and subjective effort.
- **Example**:

  Apple picking task: have to decide whether to accept or reject an effortful trial to gain some reward.



Exemplar Neural Mechanisms:

- **Ventral striatum**
- **Anterior cingulate cortex (ACC)**
- **Dorsolateral prefrontal cortex (DLPFC)**
- **Ventromedial prefrontal cortex (vmPFC)**
- **Dopaminergic midbrain**



Culbreth et al., 2016; Bortolon et al., 2018 ; Petitet et al., 2021; Torrente et al., 2011; Verdejo-García et al., 2006; Raffard et al., 2020; den Brock et al., 2015

Alterations of effort-based decision making

Apathy: A state of diminished motivation, reduced goal-directed behavior, and lack of interest or enthusiasm.

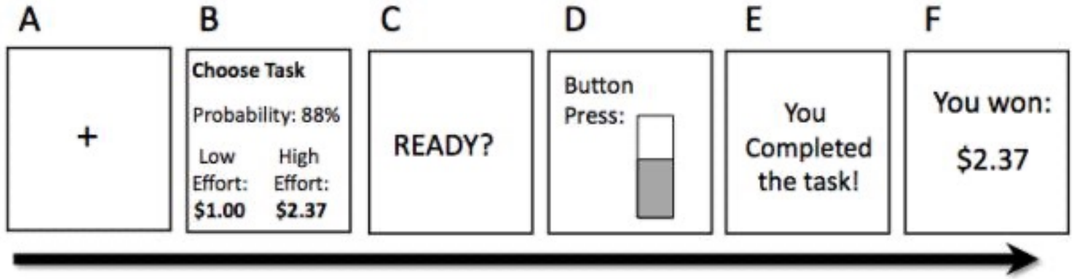
Impaired effort-based decisions: Individuals with apathy may:

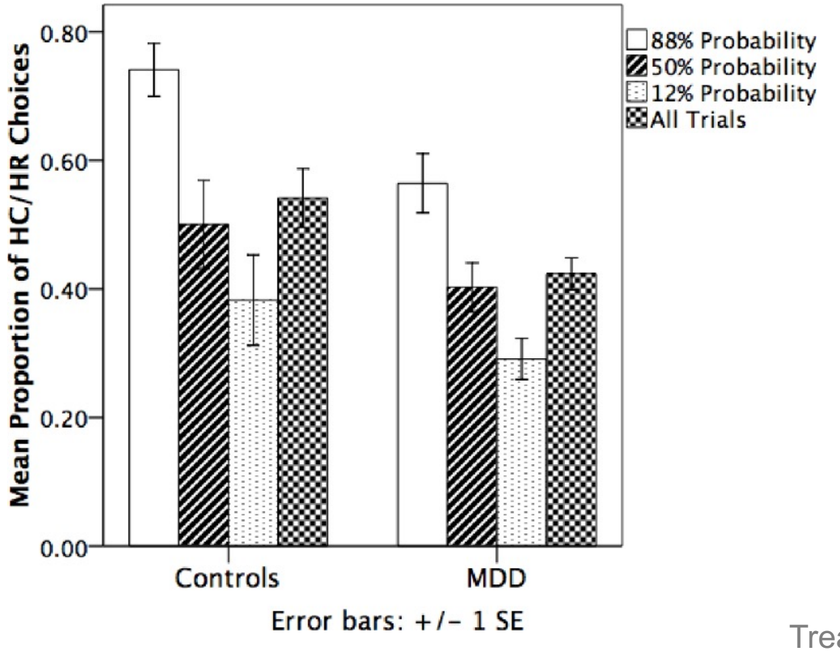
- Be less willing to exert effort, even for rewarding tasks
- Show reduced sensitivity to potential rewards
- Have difficulty initiating or sustaining effortful activities

Relevant disorders:

- Parkinson's disease
- Depression
- Schizophrenia and psychosis
- Attention deficit-hyperactivity disorder (ADHD)
- Addiction
- Obsessive-compulsive disorder (OCD)

Depression



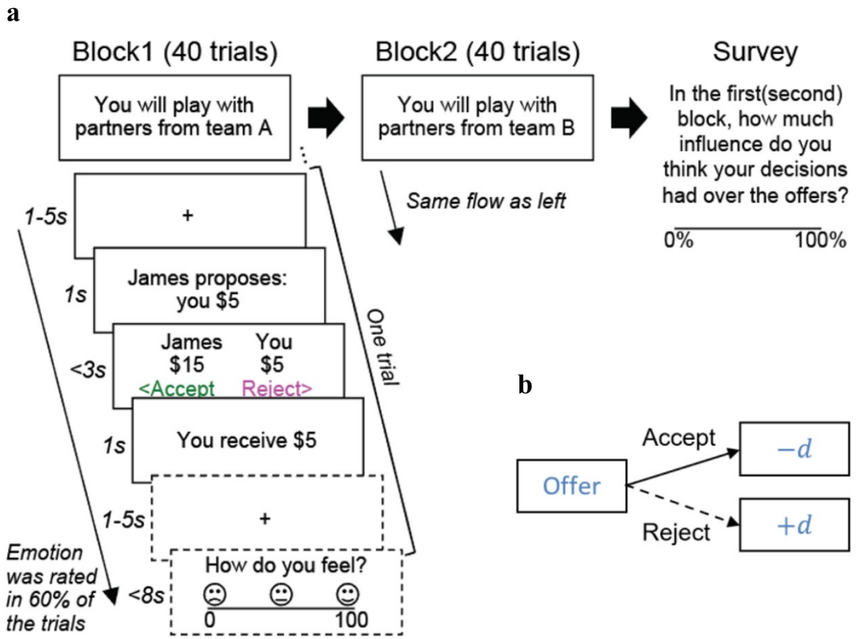


Treadway et a., 2012

Social decision making

- **Focus**: Choosing between options that affect not only oneself but also others, often involving cooperation, competition, and moral considerations.
- **Primary Motivator**: Self-interest, pro-sociality, fairness
- **Example**:

  Ultimatum game



Exemplar Neural Mechanisms:

- **Prefrontal cortex**
- **Insula**
- **Amygdala**
- **Anterior cingulate cortex (ACC)**
- **Temporoparietal junction (TPJ)**
- **Superior temporal sulcus (STS)**

Na et al., 2021

Alterations of social decision making

Autism spectrum disorder (ASD)

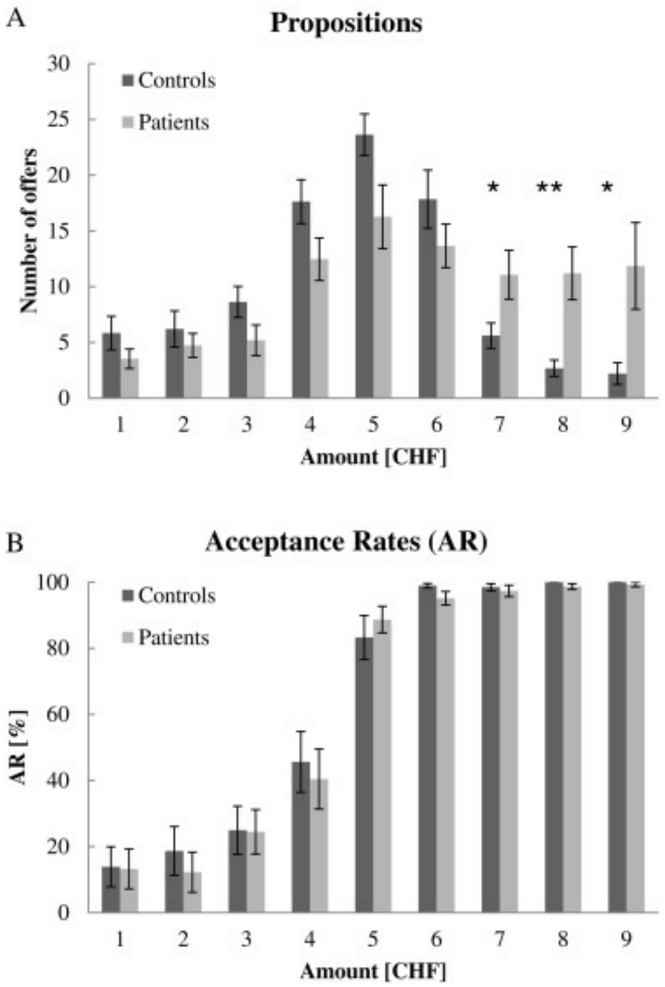
In the Ultimatum Game:

- Children with ASD were 37% less likely to reciprocate fair offers
- 22% less likely to reciprocate unfair offers.

Participants with ASD seem to adapt their behavior less.

Hartley & Fisher, 2018

Schizophrenia



Horat et al. 2018

Thank you!

Any Questions?

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Next Class: Guest Lecture on ”Science and Ethics”
by Dr. Matan Mazor

Tuesday the 9th of July
9:30am-10:30am