Revisiting the Neural Architecture of Adolescent Decision-Making: Univariate and Multivariate Evidence for System-Based Models

João F. Guassi Moreira, Adriana S. Méndez Leal, Yael H. Waizman, Natalie Saragosa-Harris, Emilia Ninova, and Jennifer A. Silvers

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ASHLEY MALKIN & SAHANA MURALI

Outline

- Background
- Methods
- Results
- Discussion/Analysis
- Limitations

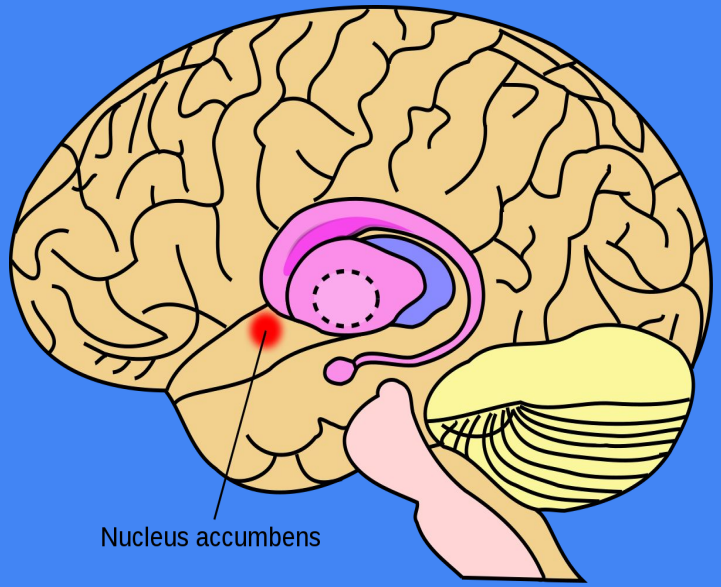
Background

- The system based theories lack scientific support, so this paper overcomes the limitations to test the validity of system-based models for predicting risky decision-making.

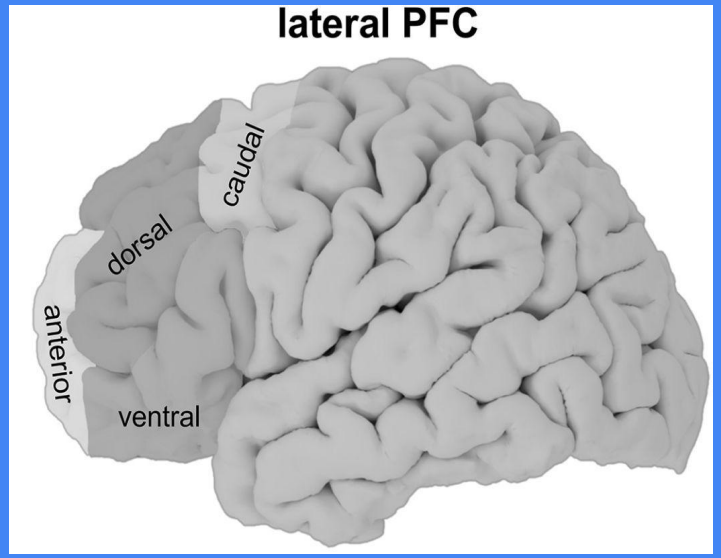
Terms to be known:

- Value-based system Vs Cognitive control system
- Influential Theories Vs ***System based Theories***
- Univariate Modeling Vs Multivariate Modeling

Important brain areas:



MODULATING IMMEDIATE REWARDS, MOTIVATION & PLEASURE PROCESSING.



RESPONSIBLE FOR THE IMPLEMENTATION OF COGNITIVE CONTROL - Affected by reward

Background

- *Value-based system*: Increases probability for risk-taking and is primarily housed in Nucleus Accumbens (NAcc). It prioritizes immediate rewards.

- *Cognitive control system*:Restrains former system to avoid risks and is primarily housed in lateral prefrontal cortex (LPFC).

Background - Influential Vs System-based theories

INFLUENTIAL THEORIES	SYSTEM BASED THEORIES
Psychological basis.	Neurobiology basis.
Uses brain mapping.	Uses brain modeling.
Predicting brain from behaviour.	Predicting behavior from brain.

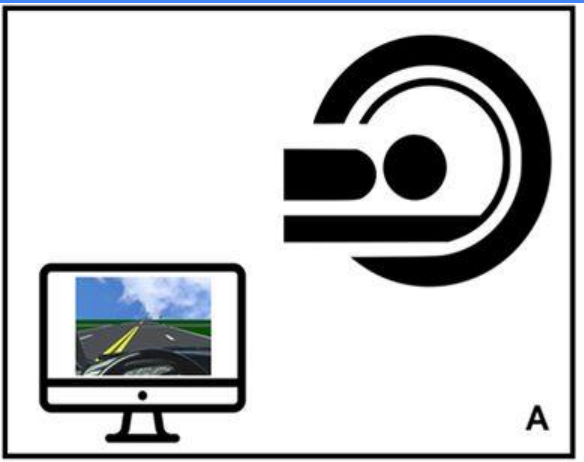
Background - univariate/multivariate modeling

UNIVARIATE MODELING	MULTIVARIATE MODELING
Classical modeling.	Switchboard modeling.
Considers particular ROI.	Considers patterns of activity across the brain.
Uses only one dependent variable.	Uses more than one dependent variable.

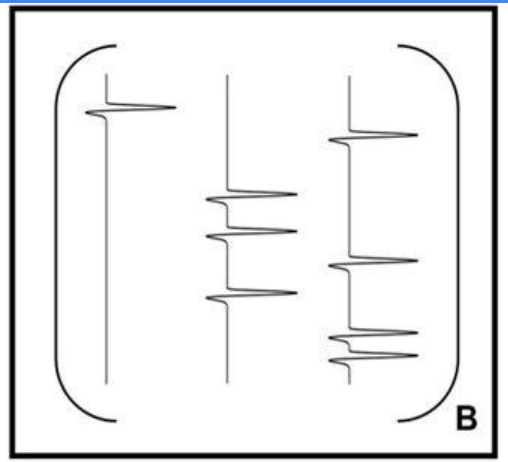
Samples:

- Participants: N = 51
  - Mean age = 15 yrs
  - Range = 9-22 yrs
  - Gender = 25 females
- Participants belonged to 8 different types of races and few declined to report their race.

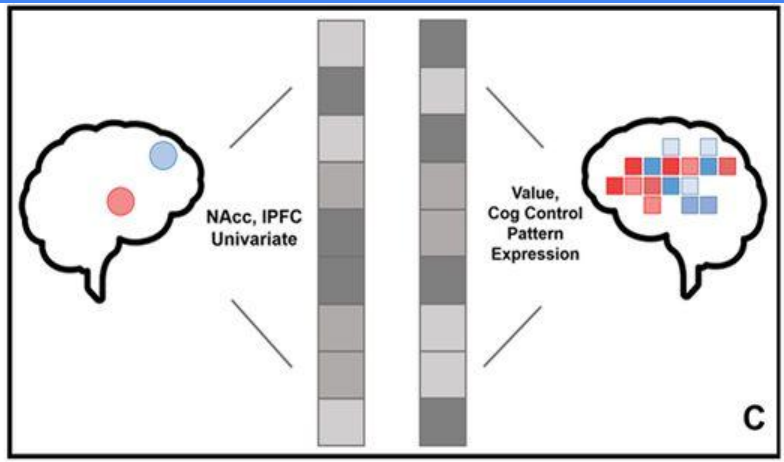
Figure 1 (methods model)



Yellow Light Game
(Acquisition)



Least Squares Single
(Preprocessing)



Calculating Brain Activity Metrics
(Univariate Activity, Pattern Expression Analysis)

YLG VIDEO

Methods:

EXPERIMENTAL DESIGN:

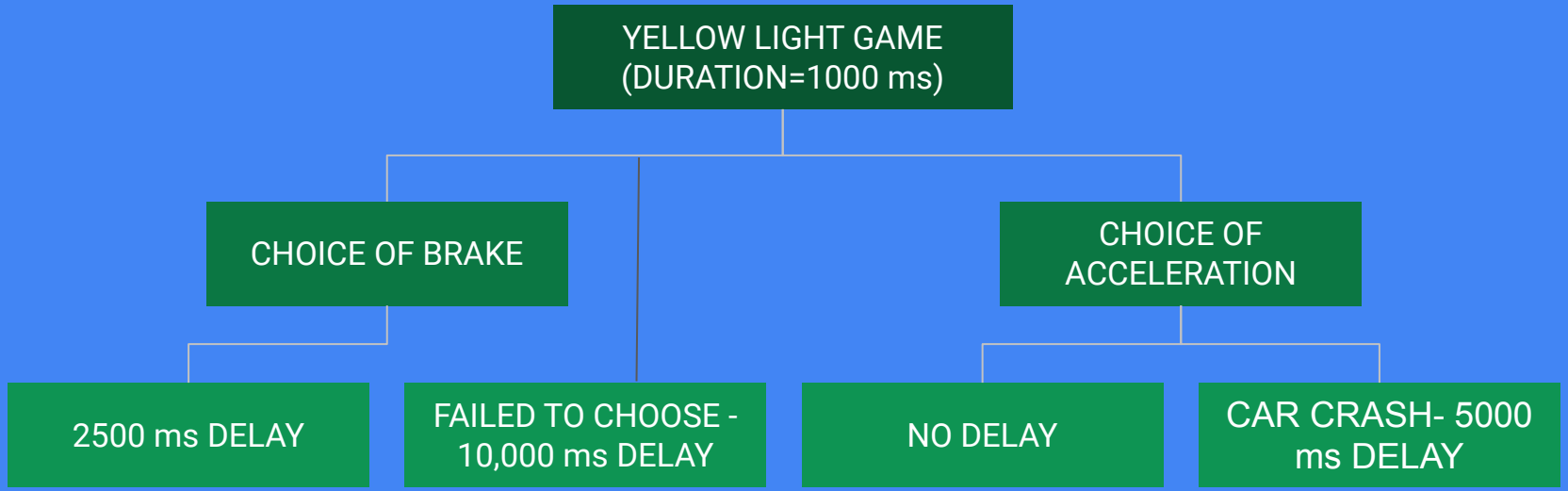
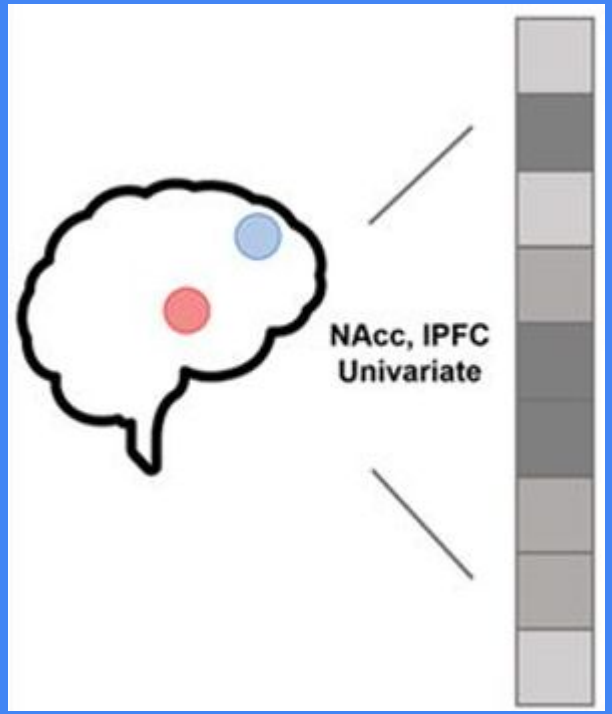


Figure 2 - Univariate Extractions from Single Trial Estimates (Classical Model)



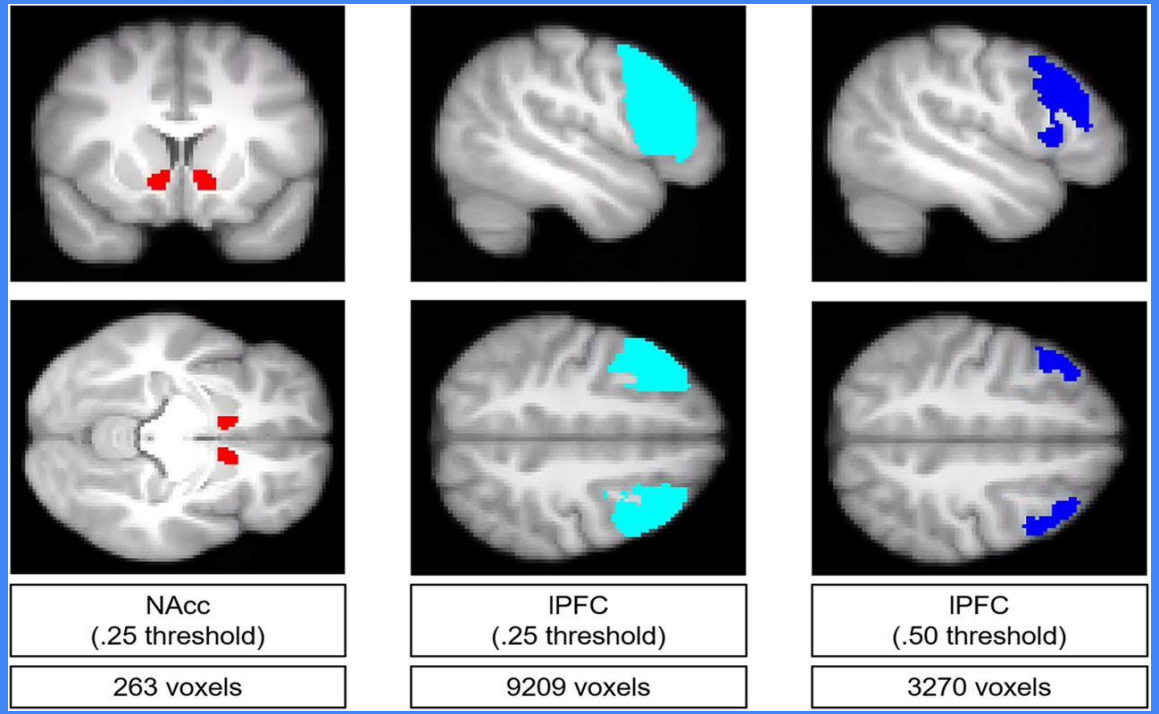
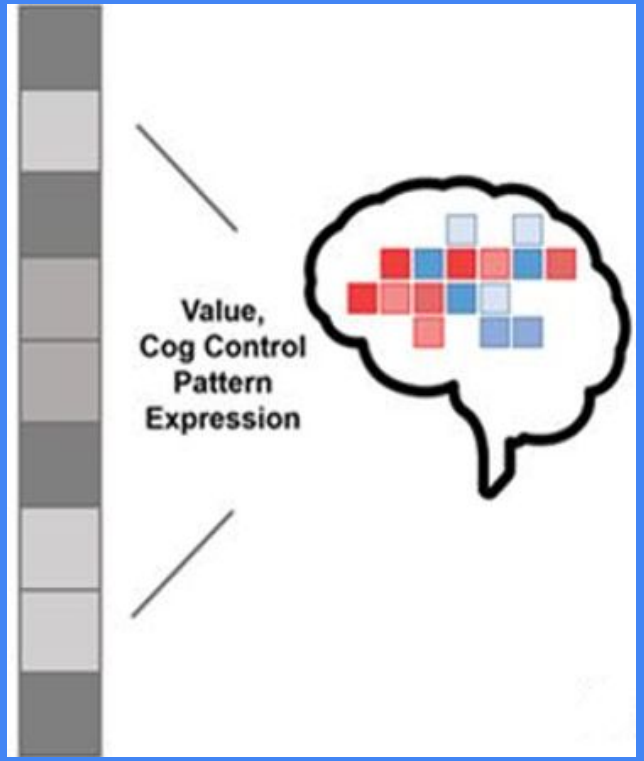


Figure 3 - Multivariate Extractions (Switchboard Model)



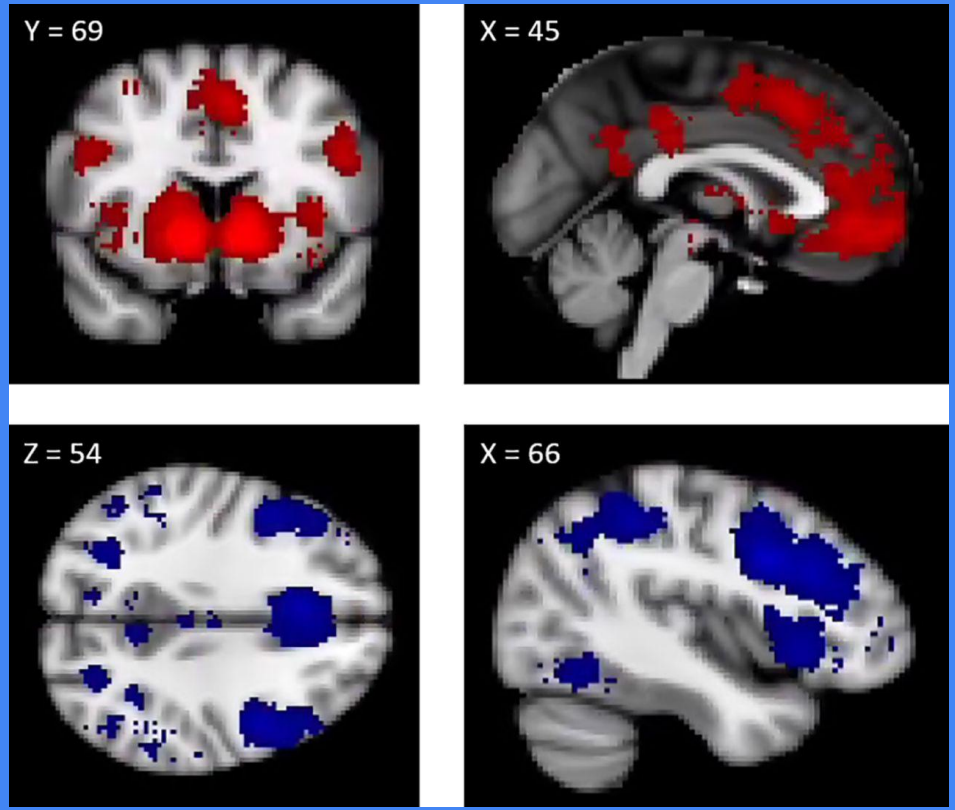
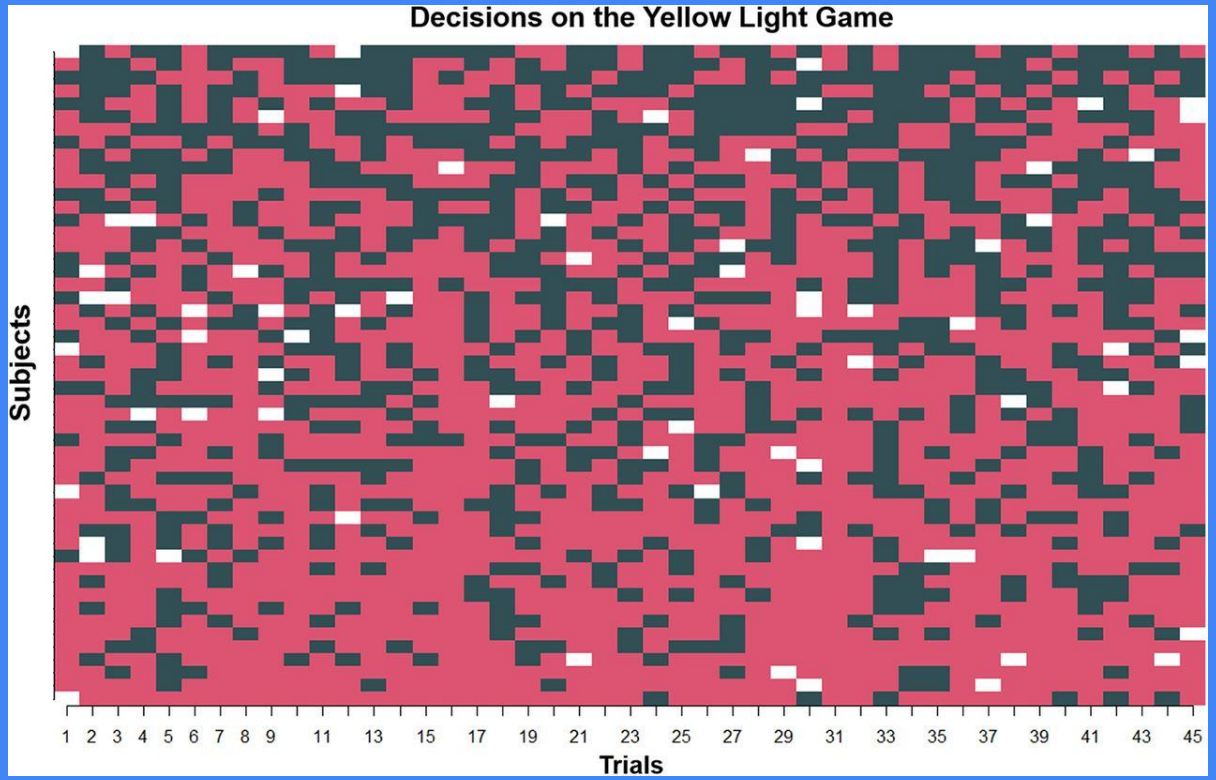


Figure 4 - Visualization of the Risky vs Safe Decisions by Adolescent Participants



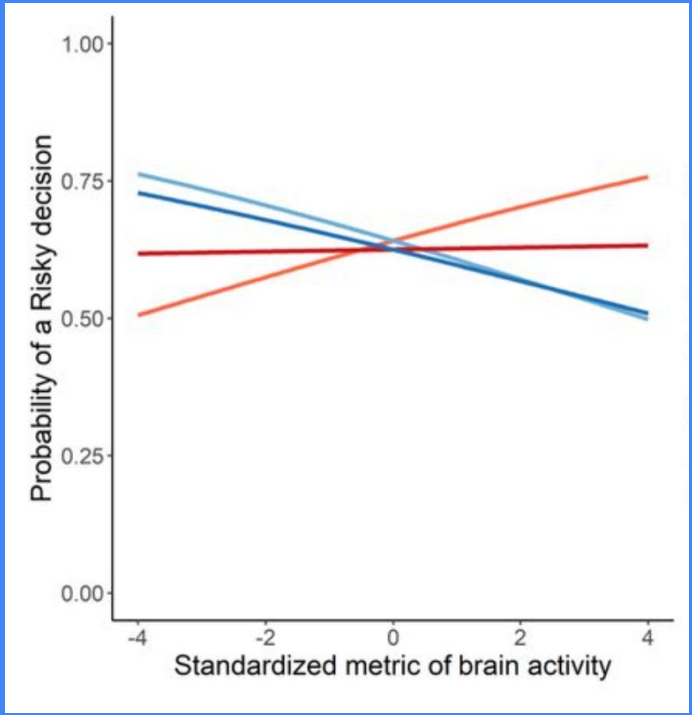
Key:

Red → Risky decision

Black → Safe decision

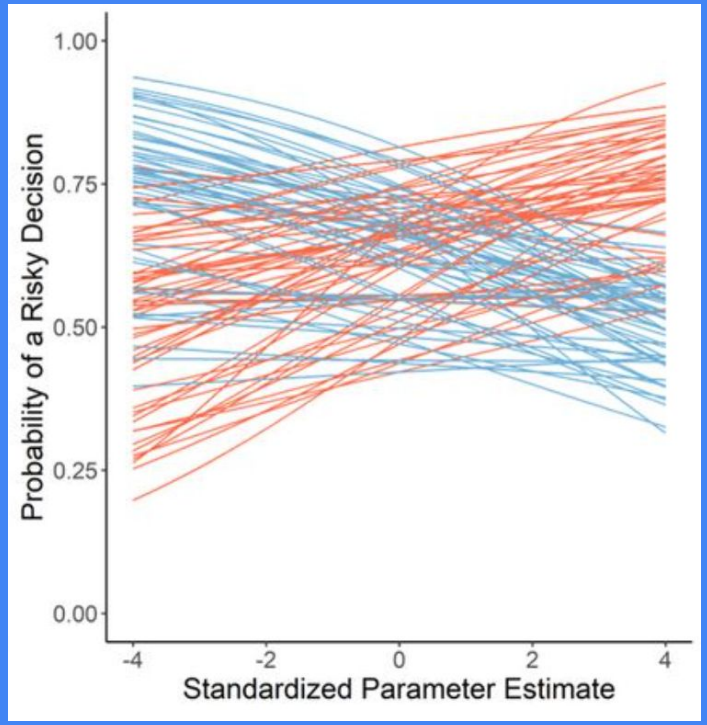
White → No decision

Figure 5 - Probability of a Risky Decision based on Multiple Models of Cognition



Within Subject

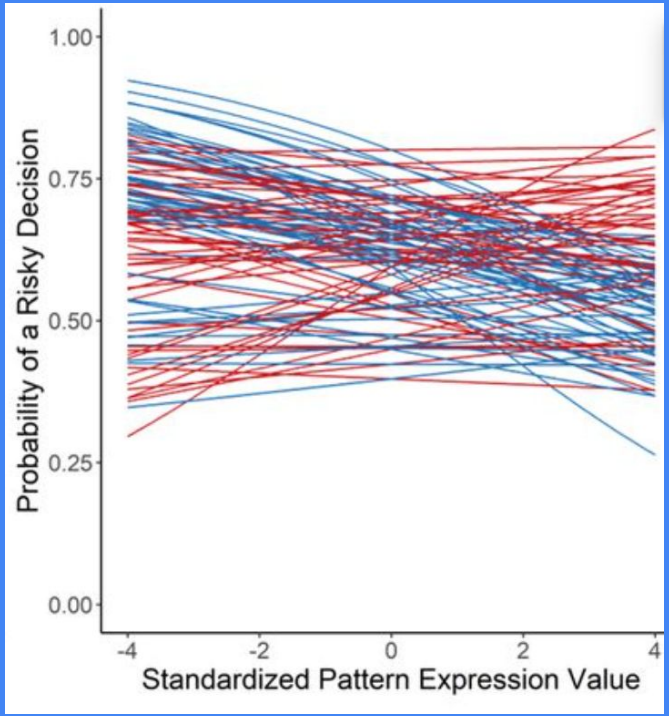
Figure 5 - Probability of a Risky Decision based on Multiple Models of Cognition



Within Subject

Univariate models

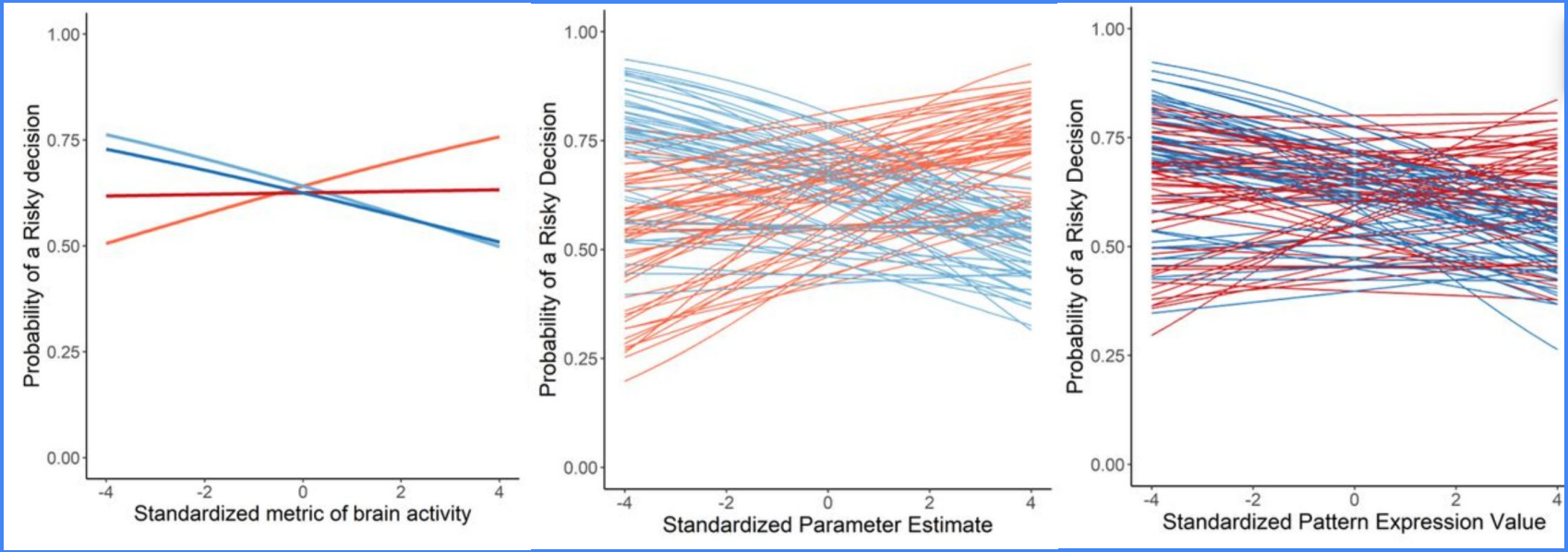
Figure 5 - Probability of a Risky Decision based on Multiple Models of Cognition



Within Subject

Multivariate models

Figure 5 - Probability of a Risky Decision based on Multiple Models of Cognition



Within Subject Findings

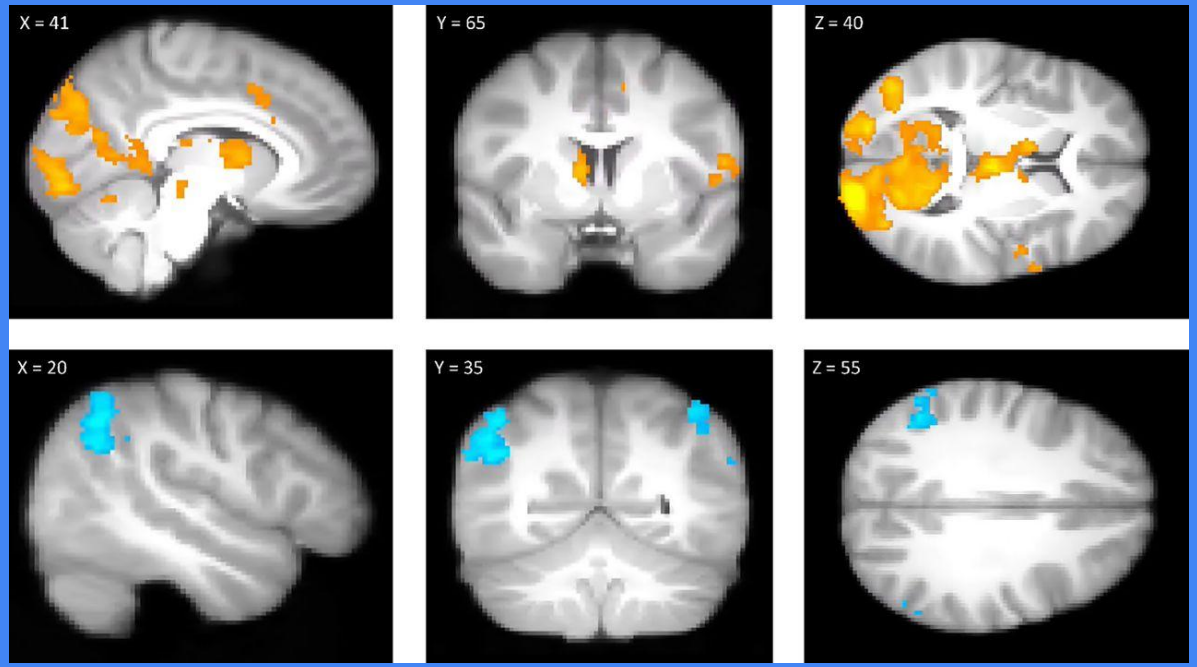
- *CLASSIC:*

  1) *NAcc:* 1 unit of increase → 15.03% of increase in probability of risk-taking.
  2) *LPFC:* 1 unit increase → 13.67 % of decrease in probability of risk-taking.

- *SWITCHBOARD:*

  1) *Cognitive control PE:* 1 unit of increase → 11.57% of decrease in probability of risk-taking.
  2) *Value-based PE:* Not significant. On adding gini-coefficient → more uniform activity in NAcc is seen.

Figure 6 - Contrasting Activity in High Risk (top row) and Low Risk (bottom row) Participants



Between Subject

Between Subject brain activity metrics were non-proportional to risky decision making.

Conclusion

- Under univariate modeling, there is a directly proportional relationship between NAcc brain activity and risk taking, and inversely proportional for LPFC

- Under multivariate modeling, there is no significant relationship between Value Pattern Expression activity and risk taking, whereas there is a negative correlation between Cognitive Control Pattern Expression activity and risk taking.

Limitations

- Sample Size
- Social/Economic Factors
- Lack of Diversity

Proof of concept vs generalizable