Modelling State-Dependencies on Human Risky Choice

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Preregistration

BACKGROUND

- Processing risk and probabilities is central to various decision-scenarios
- **Risky decision-making** can potentially be influenced by homeostatic states
  - Hungry participants make riskier choices[1,2]
  - Sleep deprived participants make riskier choices[3,4]
- **Ghrelin** levels increase in preparation of food[5] and it place a role in sleep modulation[6]
- Ghrelin might influence risky decision-making by its interaction with the dopaminergic reward system[7,8]

→ In two separate studies we manipulated ghrelin levels in healthy men. We expected higher ghrelin levels to be related to increased risky decision-making.

METHODS

Design

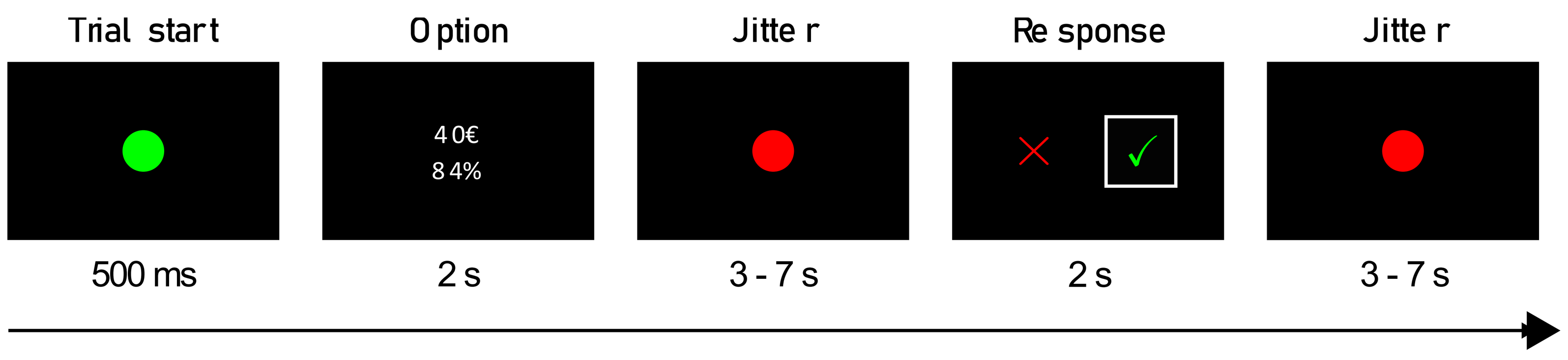

Figure 1. *Schematic Illustration of an Example Trial.* Probability discounting paradigm where participants chose between a safe option (€20 at 100%) and the risky option presented on screen. No feedback was given.

Study 1: Fasting
- $N = 37$ (26 fMRI analysis) right-handed men
- Sated (SAT)
  - 2 hr 52 min (± 1 hr 8 min) since last meal
- Fasted (FAS)
  - 8 hr 19 (± 27) min since last meal

Study 2: Sleep deprivation
- $N = 40$ (34 fMRI analysis) right-handed men
- Night of normal sleep (NNS)
  - 6 hr 44 (± 56) min average sleep duration
- Total sleep deprivation (TSD)
  - One night kept awake at institute

Both studies
- Within-subjects
- Counterbalanced
- 3T fMRI
- Blood samples
  - **Ghrelin**
  - Leptin
  - Insulin
  - Cortisol
  - Glucose

Computational Modelling

Hierarchical Bayesian modelling with RStan[9]
- **Prospect theory model**[10]
  - Attractiveness to risk δ
  - Sensitivity to probability γ
  - Decision noise β
- Hyperbolic discounting model

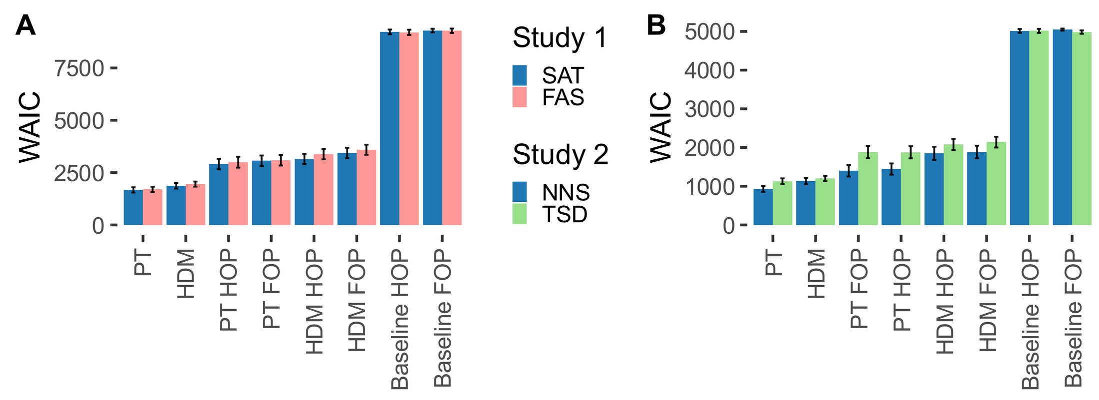

Figure 2. *WAIC Scores of Model Space.* The mean WAIC scores for each model per condition (error bars show the standard error) for study 1 (A) and study 2 (B).

Base models were expanded with different perseveration terms[11]
- First-order perseveration (FOP)
  - Based on action of previous trial only
- Higher-order perseveration (HOP)
  - Based on actions over longer period in history

RESULTS

Risky choices

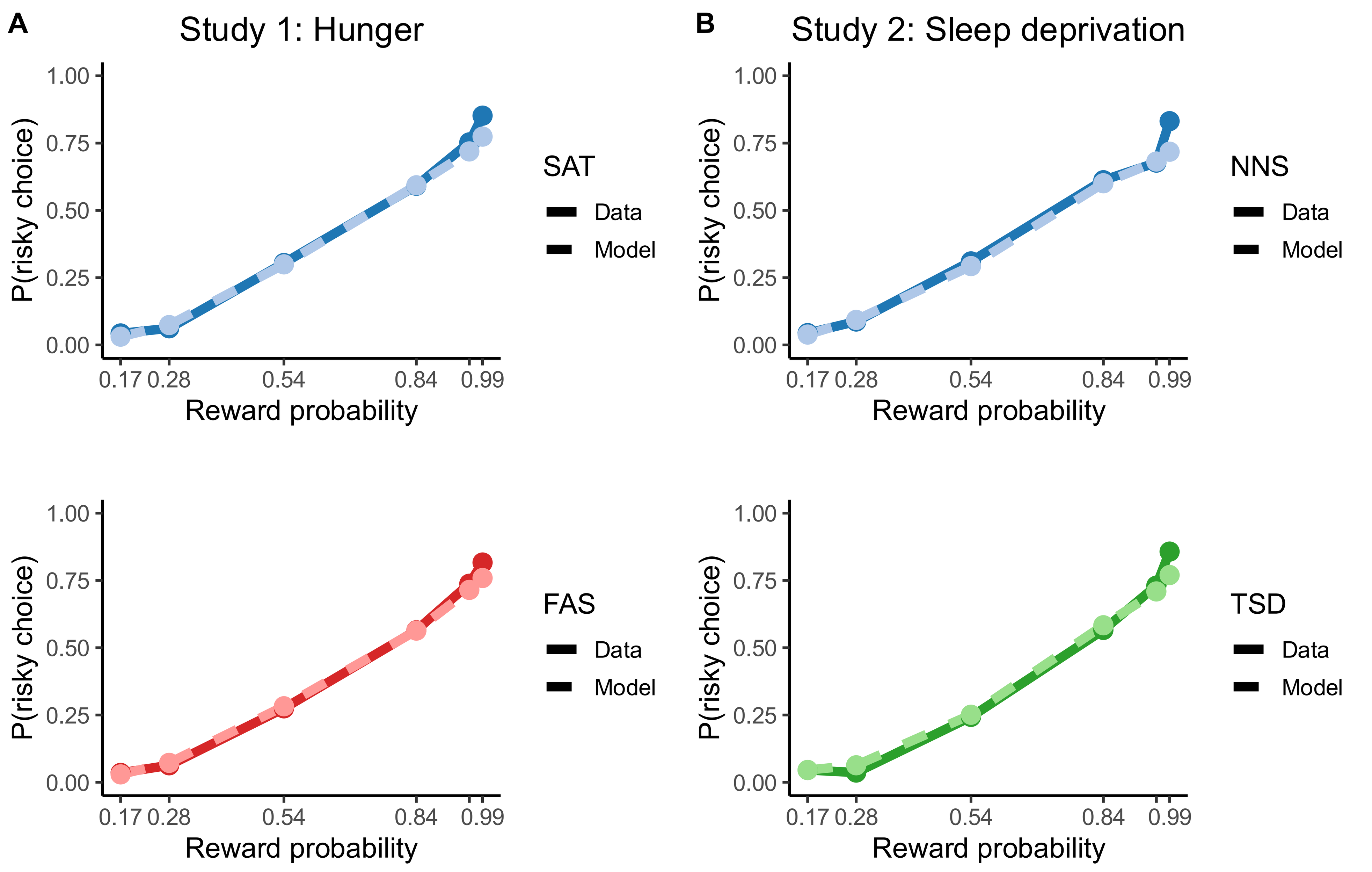

Figure 3. *Behavioural Data and Choice Predictions.* The probability of selecting the risky option per reward probability (0.17,0.28,0.54,0.84,0.96,0.99) for participants (full line) and simulated by the prospect theory model (dashed line). The behavioural data showed no difference between conditions in study 1 ($Mdn_{SAT} = 0.45, Mdn_{FAS} = 0.39, BF = 0.31 \pm 0.04\%$) and study 2 ($Mdn_{NNS} = 0.38, Mdn_{TSD} = 0.44, BF = 0.52 \pm 0.03\%$).

RESULTS

Model-based

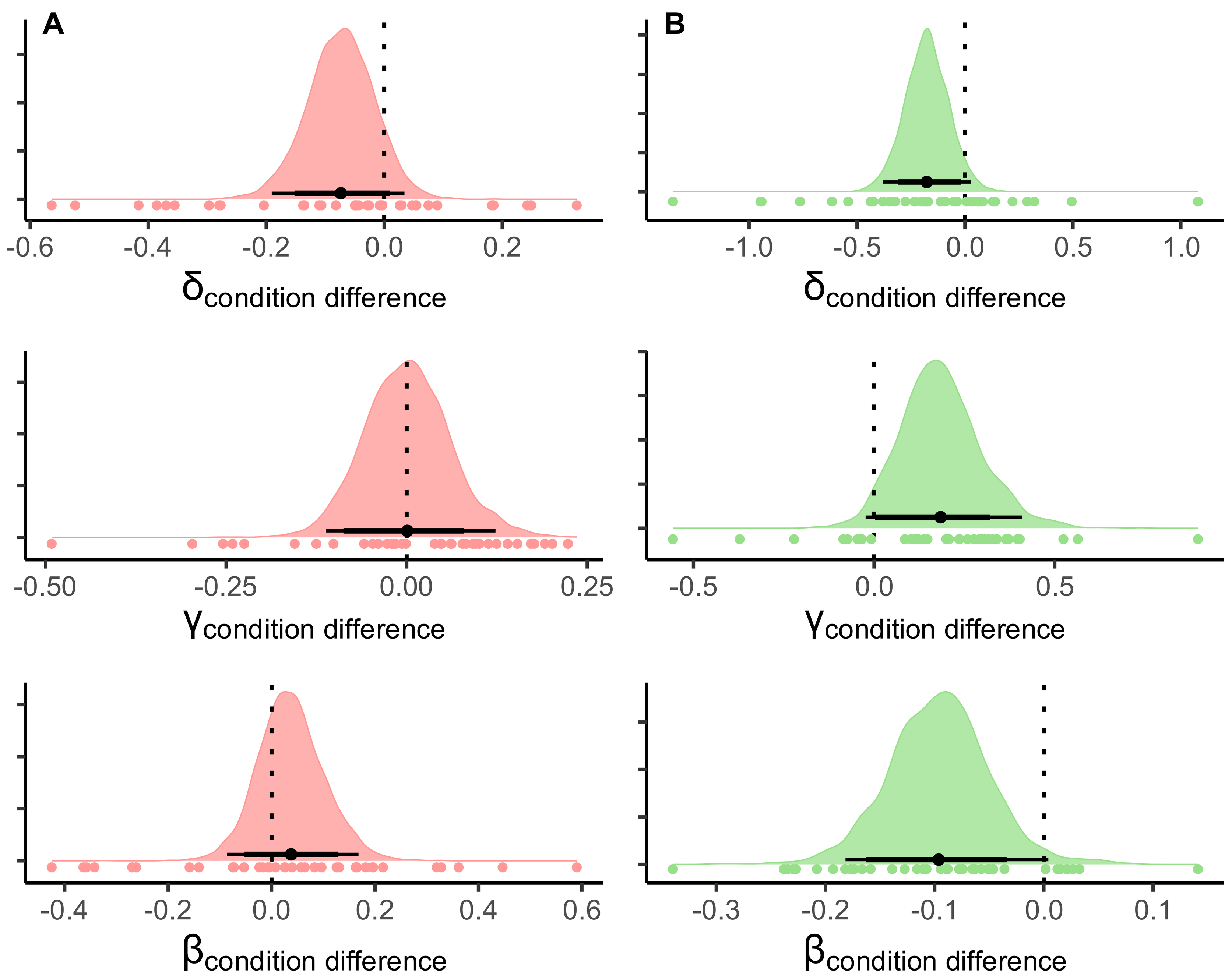

Figure 4. *Posterior Distribution of Condition Difference in Group-Level Parameters of the Prospect Theory Model.* The difference between conditions in parameter values for study 1 (A; red) and study 2 (B; green). The horizontal lines represent the highest distribution interval (HDI) of 95% (thin line) and 85% (thick line), with the mean of the distribution as dot.

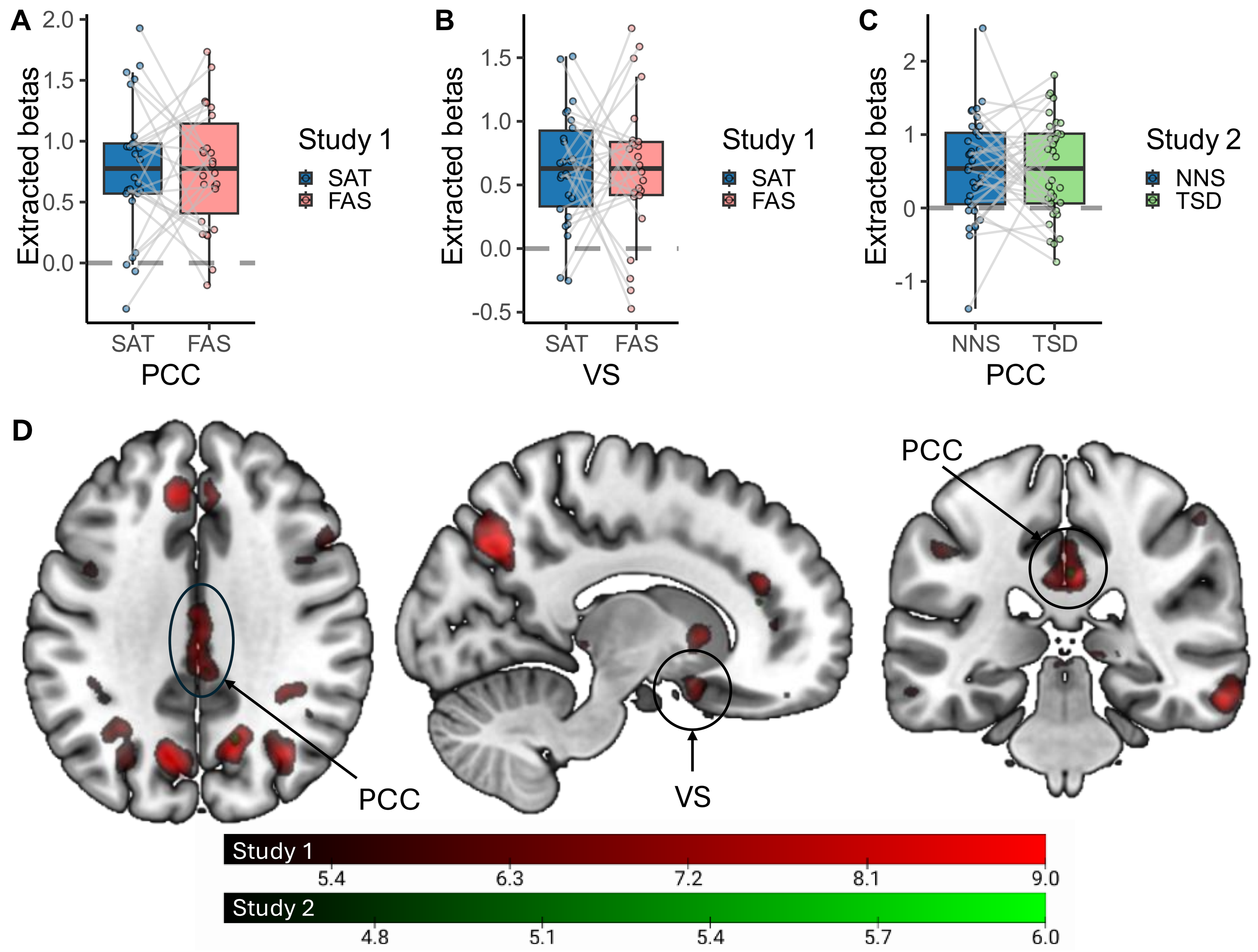

Figure 5. *Neural Activity Related to Subjective Value.* A-C) The extracted β-coefficients of subjective value in the right PCC (A; $X = 2, Y = -32, Z = 38$) and VS (B; $12, 11, -14$) for study 1, and the right PCC (C; $2, -32, 34$) for study 2. The β-coefficients support the finding of a main effect of subjective value but no effect of condition. D) Clusters with significant activity for subjective value for study 1 (red) and study 2 (green). Slices, made on $X = 13, Y = -32, Z = 34$, support the overlap between studies. However, the activity in study 2 is smaller than in study 1.

CONCLUSION

Risky decision-making does not increase after fasting or one night of total sleep deprivation
- Not in proportion of risky choices
- Not in underlying processes according to prospect theory
- Not in neural activity

→ Our results suggest that state-mediated influences, in particular from ghrelin, in risky decision-making may be weaker than previously thought.

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