



Overestimated Environmental Volatility Underpins Aberrant Decision Making in Type-I Bipolar Disorder

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Introduction

- Bipolar Disorder (BD) is a severe mood disorder characterized by recurrent mood episodes of mania and depression.
- Recent studies suggest that mood instability in BD may arise from altered reward perception and learning during decision making [1], [2].
- One key component of decision making is the inference of **environmental volatility** — how rapidly the environment changes.
- However, Only one study [3] has investigated volatility inference in BD, and it examined only a simple environmental structure in euthymic individuals.

Aim & Research Questions

Here, we tested whether individuals with BD show altered volatility inference across diverse environmental structures and whether it is associated with clinical symptoms.

- RQ 1)** Do individuals with BD show differences in behavioral patterns?
- RQ 2)** Do individuals with BD show altered volatility inference?
- RQ 3)** How do clinical symptoms relate to individual differences in volatility inference?

Method

Participants	Mood	Measures
 HC (N=40) Type-I BD (N=32)	• Mania (YMRS) • Depression (MADRS, BDI) Trait Hypomanic Personality Trait	Motivational system • BIS/BAS Impulsiveness • BIS-11 Cognitive function • IQ • Working memory

PRL (Probabilistic Reversal Task) [4]

PTT (Probability Tracking Task) [5]

Task

Different Pattern & Source of Environmental Change

Computational Modeling

Hierarchical Gaussian Filter [6]

Level	State of the world	Variable	Possible values	Generative model
3	Log-volatility of tendency	x_3	Real number	Gaussian random walk with constant step size θ
2	Tendency towards category "1"	x_2	Real number	Gaussian random walk with step size $\exp(\alpha_2 x_2)$
1	Stimulus category	x_1	"1", "0"	Sigmoid transformation of x_2

Parameter of interest

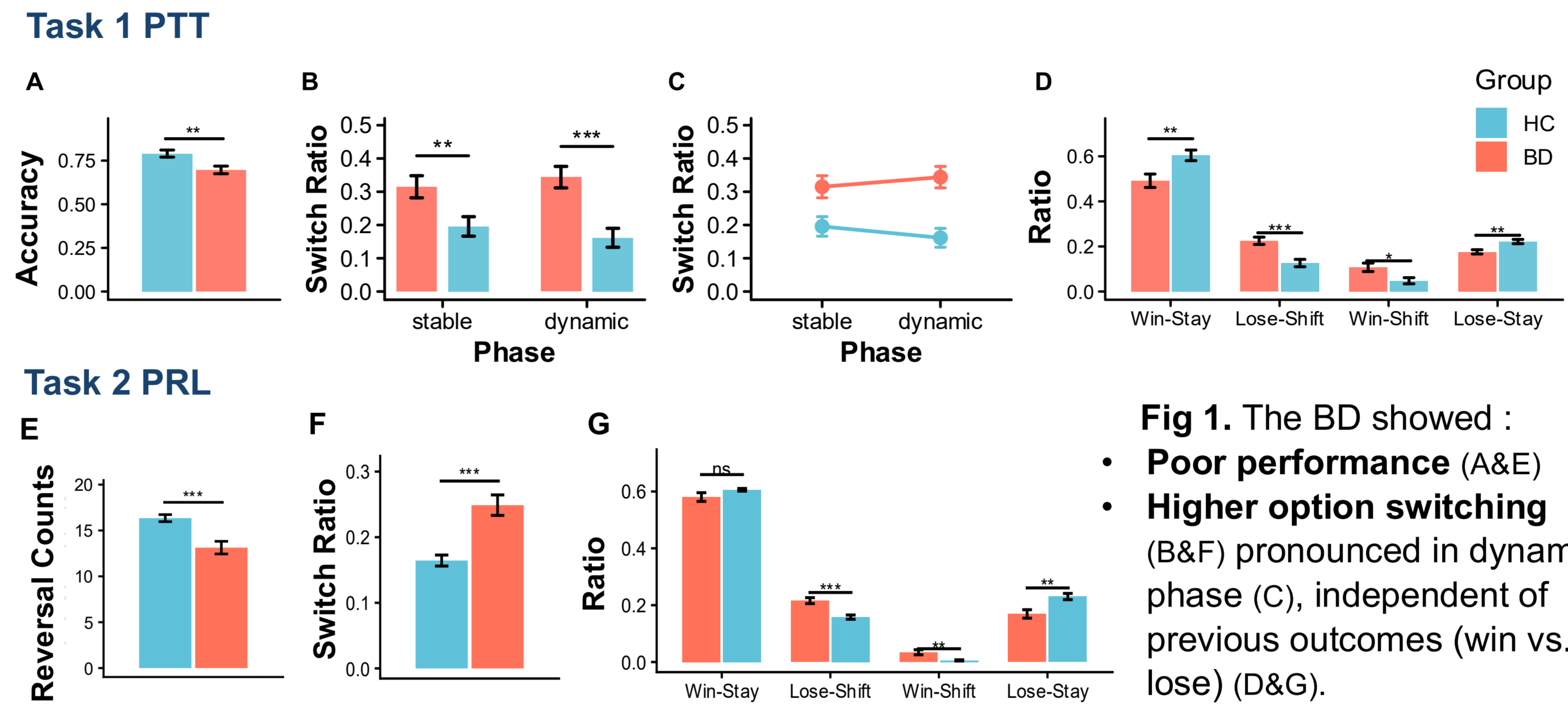
- μ_3^0 : Prior Belief about Environmental Volatility
- ζ : Behavioral Stochasticity

• Infer trial-wise hierarchical belief of the participant from behavioral data.

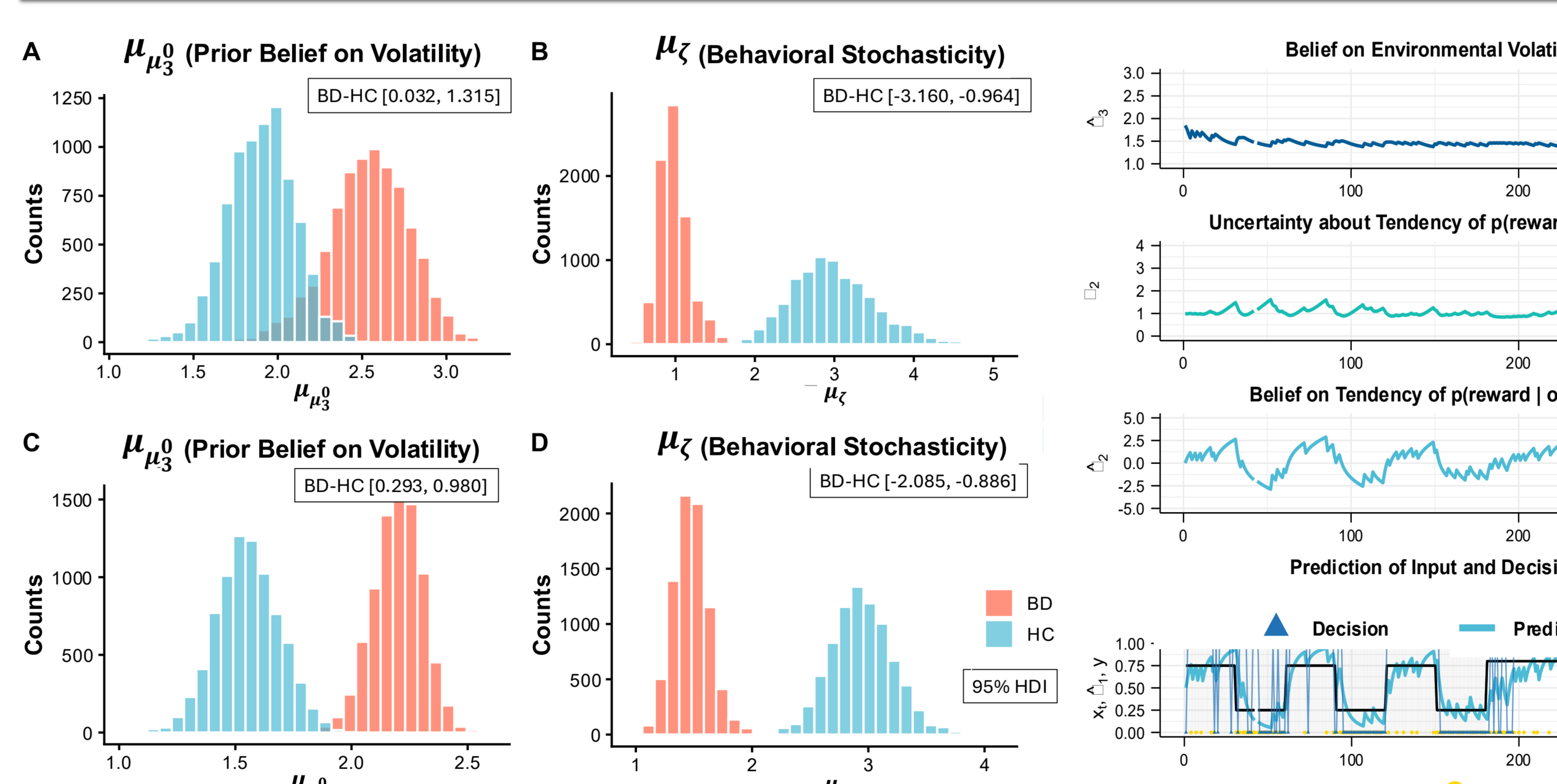
Hierarchical Bayesian analysis Estimate and compare group level parameter [7].

Results

Result 1. Group Differences in Behavioral Patterns



Result 2. Group Differences in Perceptual Parameter



Result 3. Association with Clinical Variables

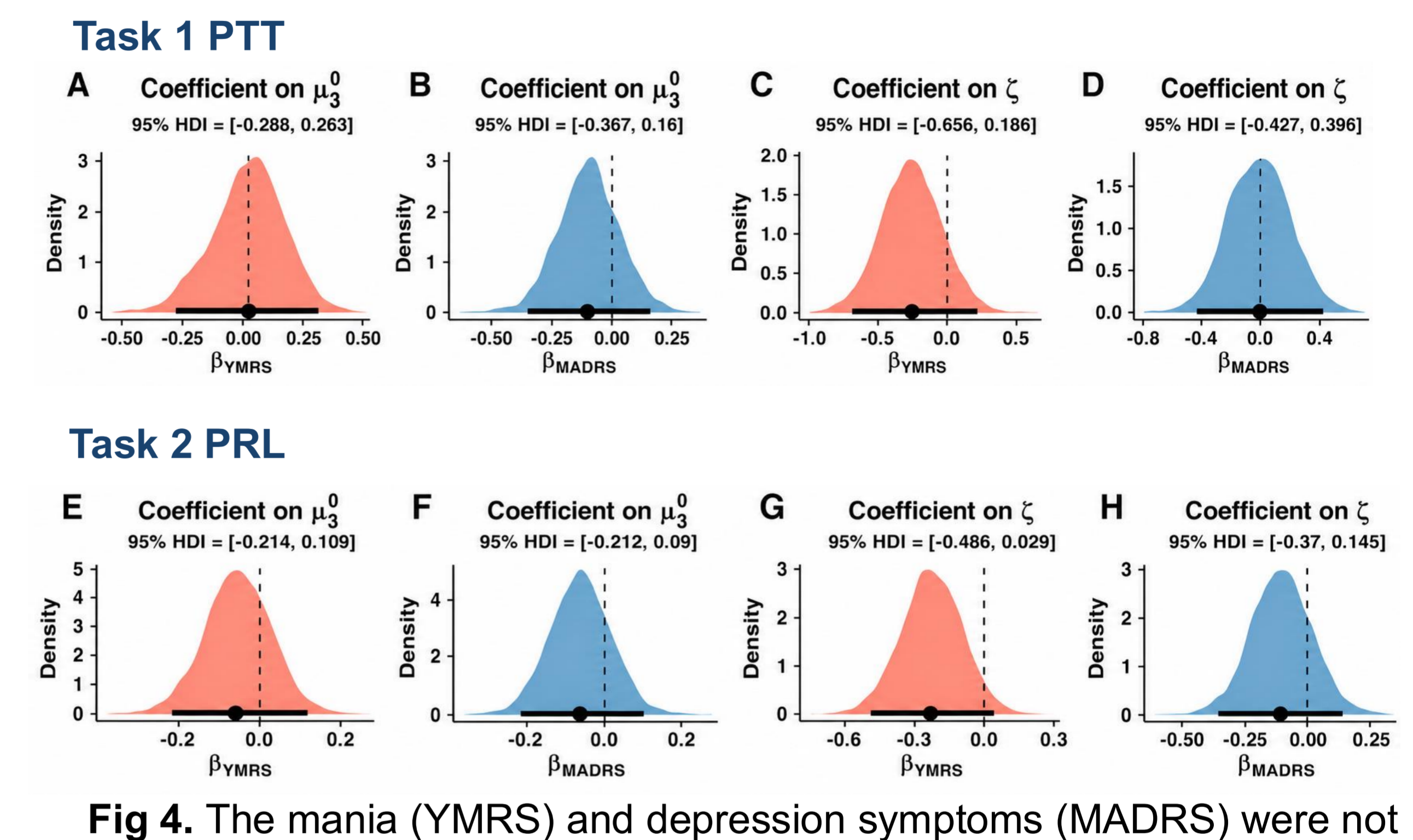


Fig 2. Group posterior distributions of HGF parameters of PTT (A&B) and PRL (C&D). The BD exhibited higher priors on volatility and higher choice randomness, which may underlie increased switching behavior. Note. 95% Higher Density Intervals of posterior group differences are noted.

Fig 3. Belief trajectories and decisions of two representative participants whose posterior means are close to the group posterior means from each group HC (left); BD(right), in PTT.

Conclusion

Key Takeaway Type-I BD may be characterized by heightened volatility beliefs and increased behavioral stochasticity.

Clinical Implications

Explaining Clinical Symptoms Heightened volatility beliefs may lead individuals to interpret ordinary life events as signals of environmental change, potentially explaining why specific life events (i.e., personal achievements) triggers mood episodes.

Diagnostic Implication Volatility parameter was independent of depression severity – May serve as a diagnostic marker for differentiating BD from MDD.

Remaining Questions

Dependence on Episode Is altered volatility inference varies across episodes?

Origin of Altered Volatility Inference Does it precede illness onset vs. develop across episodes?

Predictive Utility Can volatility parameter improve prediction of heterogenous mood trajectories?

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