Archival Report

Biological Psychiatry

Psychiatric Symptom Dimensions Are Associated With Dissociable Shifts in Metacognition but Not Task Performance

Marion Rouault, Tricia Seow, Claire M. Gillan, and Stephen M. Fleming

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Heesun Park

Introduction

- Metacognition
  - Knowledge of one's cognitive process
  - Ability to reflect on and evaluate one's behavior
  - "How confident am I that I was correct?"
- Objective Performance vs Subjective Confidence
- GAP
  - Isolate metacognition from objective performance
  - Symptoms – metacognition

Methods

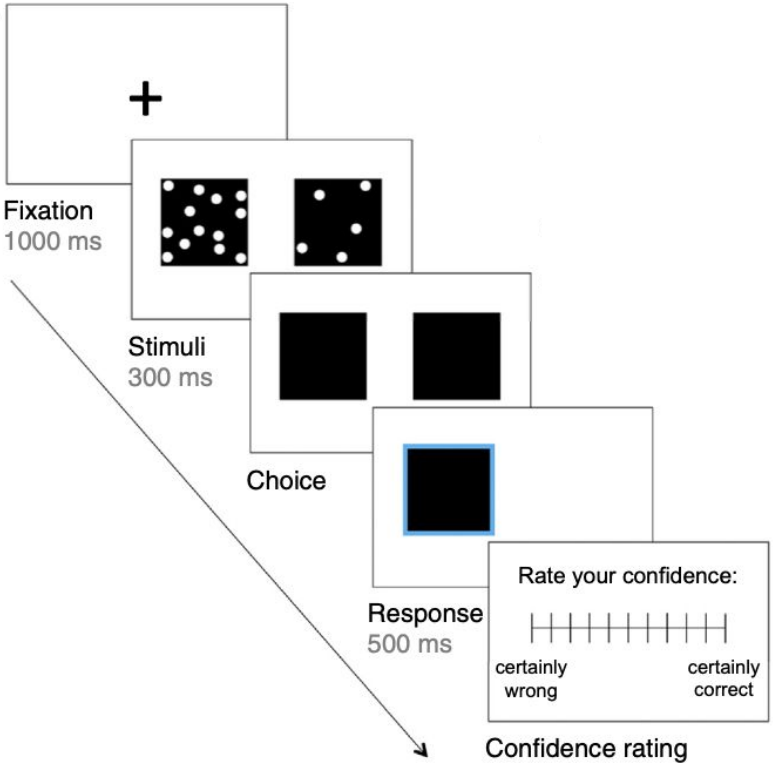
Participants & Task

Experiment 1 (663 ➡️ 498)	**Experiment 2** (637 ➡️ 497)
Perceptual Decision-making task	
210 trials in 5 blocks	
11-point probabilistic rating scale	6-point scale with verbal labels
global pre-task confidence global post-task confidence	X
X	Calibration procedure: two-down one-up staircase procedure

Methods

Task

Perceptual Decision-making



Methods

Task

Experiment 1 (663 ➡️ 498)	**Experiment 2** (637 ➡️ 497)
Perceptual Decision-making task	
210 trials in 5 blocks	
11-point probabilistic rating scale	6-point scale with verbal labels
global pre-task confidence global post-task confidence	X **Avoid possible biasing of subsequent trial-by-trial confidence ratings**
X	**Calibration procedure: two-down one-up staircase procedure** **Equate performance across individuals → Isolate metacognition from decision performance**

Methods

Self-report Psychiatric Questionnaires

Experiment 1	Experiment 2
• Depression (SDS) • Schizotypy (SSMS) • Impulsivity (BIS-11) • Obsessive Compulsive Disorder (OCI-R) • Social anxiety (LSAS) • IQ (I-CAR)	
• Generalized anxiety (GAD-7)	• Generalized anxiety (STAI) Form Y-2
	• Alcoholism (AUDIT) **Factor analysis** • Apathy (AES) • Eating disorders (EAT-26)

Methods

Models and Analyses

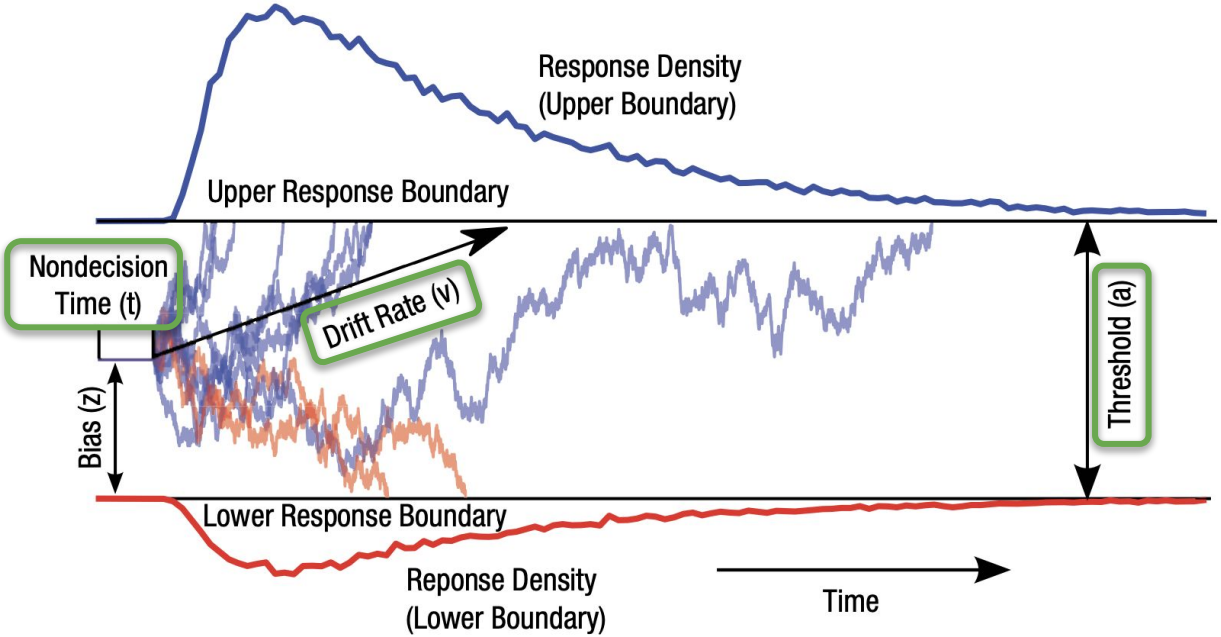
Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 Signal Detection Theory
	Factor Analysis
Linear regressions	

Methods

Models and Analyses

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Drift-Diffusion Model



Wiecki et al (2015)

Models and Analyses

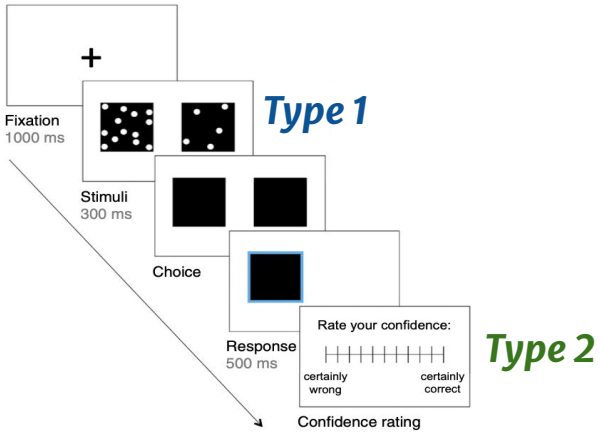
Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Metacognitive efficiency

Type 2 (metacognitive) sensitivity

$$\log\left(\frac{\text{meta-}d'}{d'}\right)$$

Type 1 sensitivity



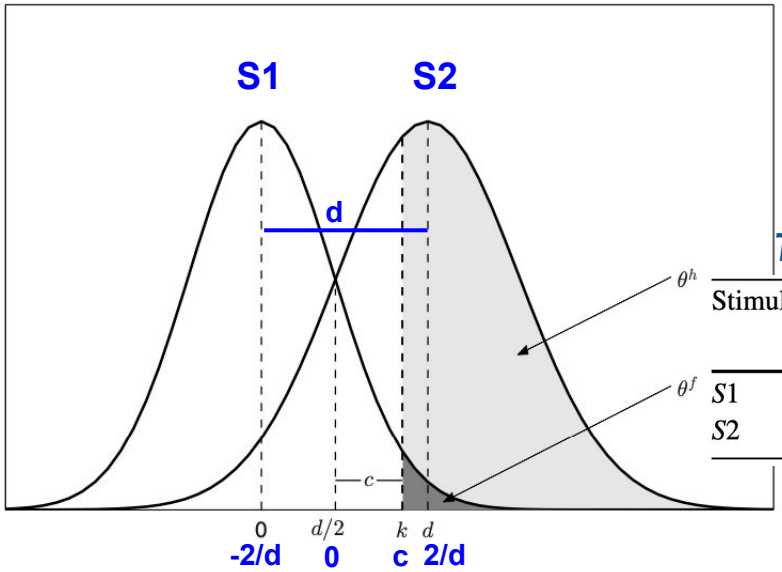
Maniscalco, B., & Lau, H. (2014)

Methods

Models and Analyses

Signal Detection Theory

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis



Type 1

Stimulus	Response	
	"*S*1"	"*S*2"
*S*1	Correct rejection (CR)	False alarm (FA)
*S*2	Miss	Hit

Lee, M. D. & Wagenmakers, E.-J. (2014)
Maniscalco, B., & Lau, H. (2014)

Methods

Models and Analyses

Type 2 SDT (meta-SDT)

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Type 1

Stimulus	Response	
	"*S*1"	"*S*2"
*S*1	Correct rejection (CR)	False alarm (FA)
*S*2	Miss	Hit

Type 2

Response			Confidence	
			Low	High
"*S*1"	Accuracy	Incorrect (Type 1 miss)	$CR_{2,\text{"S1"}}$	$FA_{2,\text{"S1"}}$
		Correct (Type 1 correct rejection)	$Miss_{2,\text{"S1"}}$	$Hit_{2,\text{"S1"}}$
"*S*2"	Accuracy	Incorrect (Type 1 false alarm)	$CR_{2,\text{"S2"}}$	$FA_{2,\text{"S2"}}$
		Correct (Type 1 hit)	$Miss_{2,\text{"S2"}}$	$Hit_{2,\text{"S2"}}$

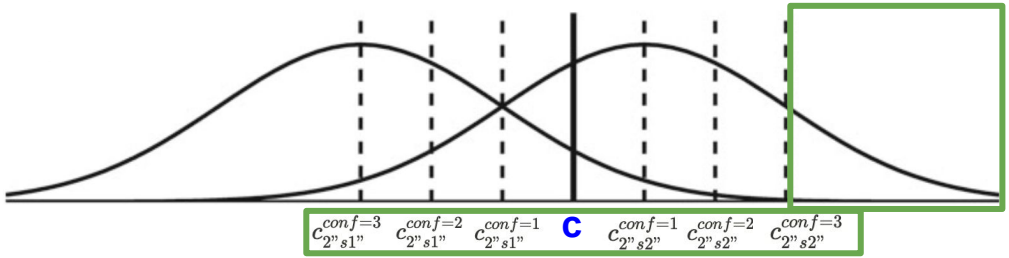
Maniscalco, B., & Lau, H. (2014)

Methods

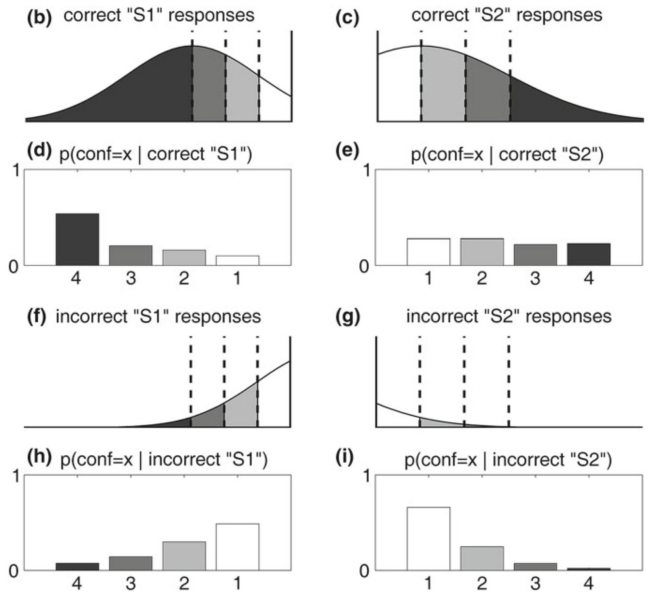
Models and Analyses

Type 2 SDT (meta-SDT)

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis



Response			Confidence	
			Low	High
"*S*1"	Accuracy	Incorrect (Type 1 miss)	$CR_{2,"S1"}$	$FA_{2,"S1"}$
		Correct (Type 1 correct rejection)	$Miss_{2,"S1"}$	$Hit_{2,"S1"}$
"*S*2"	Accuracy	Incorrect (Type 1 false alarm)	$CR_{2,"S2"}$	$FA_{2,"S2"}$
		Correct (Type 1 hit)	$Miss_{2,"S2"}$	$Hit_{2,"S2"}$



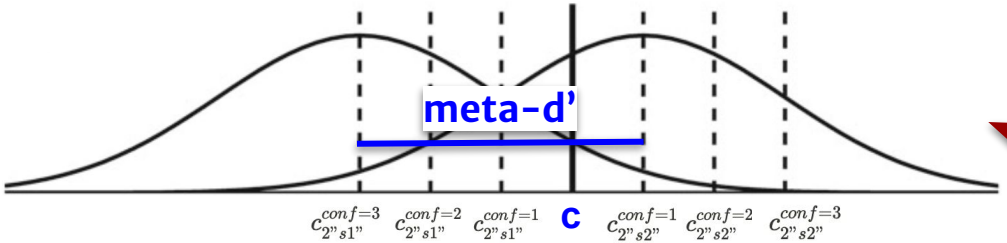
Maniscalco, B., & Lau, H. (2014)

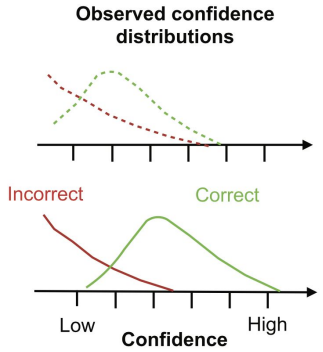
Methods

Models and Analyses

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Type 2 SDT (meta-SDT)





Maniscalco, B., & Lau, H. (2014)
Fleming, S. M. (2017)

Methods

Models and Analyses

Metacognitive efficiency

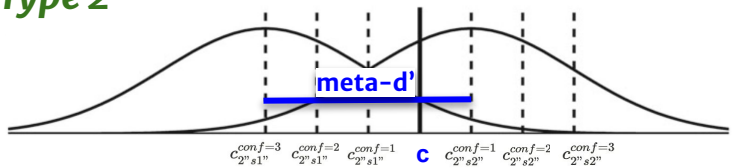
Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Metacognitive sensitivity

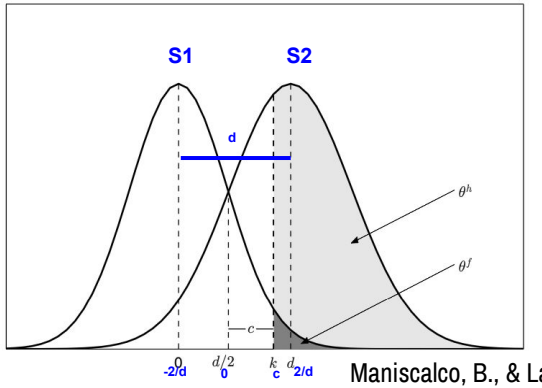
$$\log\left(\frac{\text{meta-}d'}{d'}\right)$$

Type 1 sensitivity

Type 2



Type 1



Maniscalco, B., & Lau, H. (2014)

Methods

Models and Analyses

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Factor analysis

Limitation of experiment 1

- Strong correlations between individual questionnaire scores consistent with comorbidity between constructs.
- Within a particular questionnaire, different items map onto separable latent factors

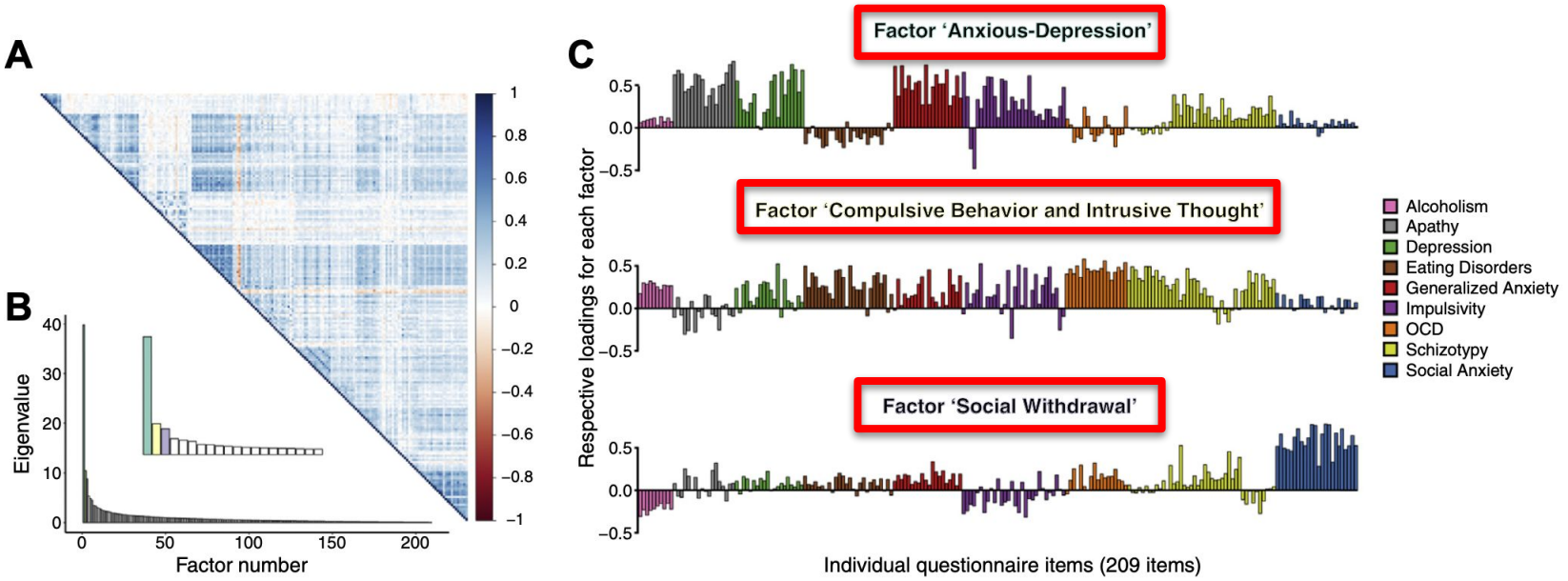
➡️ identification of underlying transdianostic psychiatric dimensions with additional questionnaires through factor analysis

Methods

Models and Analyses

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis

Factor analysis



Results

Behavioral data and DDM model fits

Experiment 1

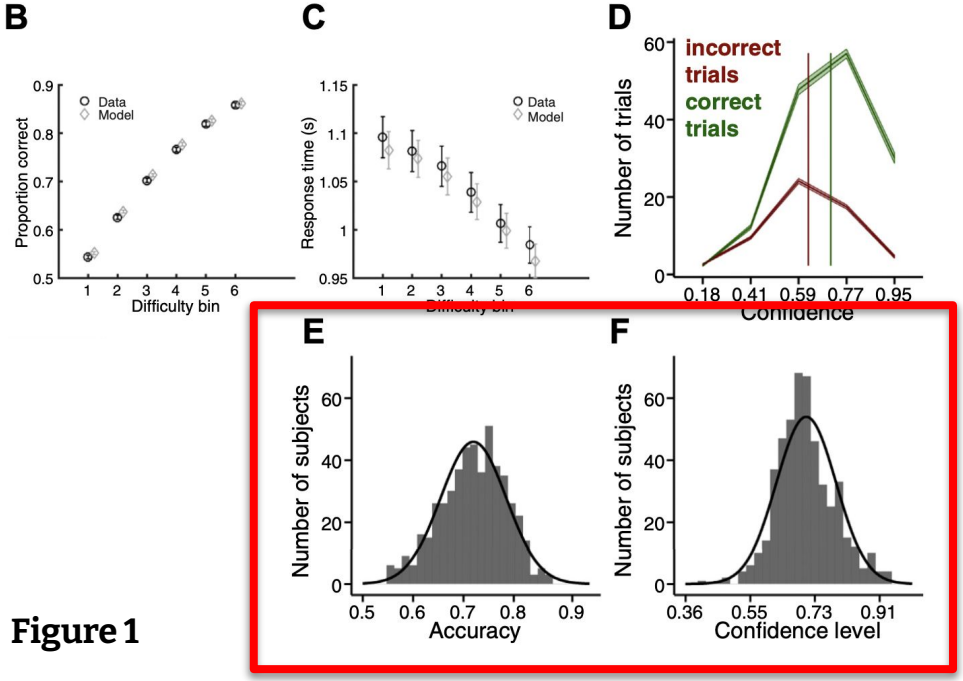


Figure 1

Experiment 2

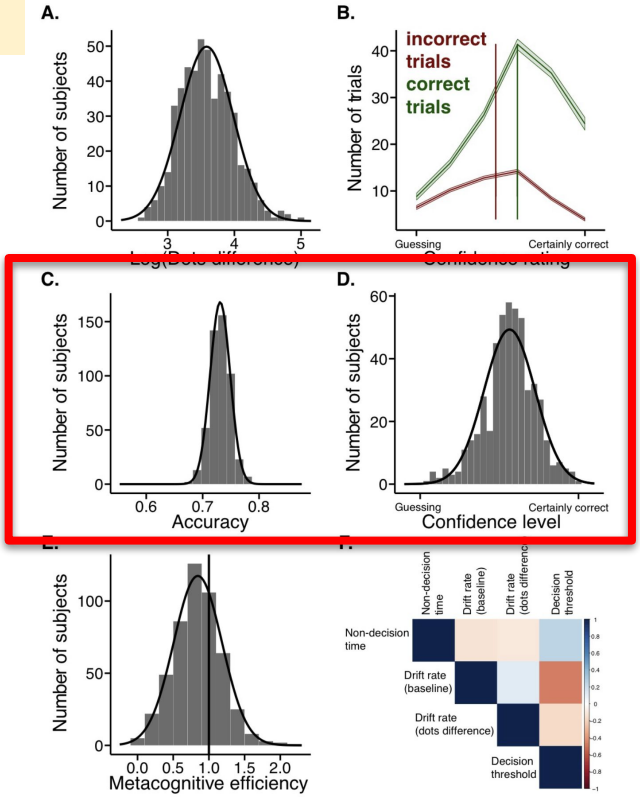


Figure S4

Results

Decision & Metacognition – Psychopathology

Experiment 1

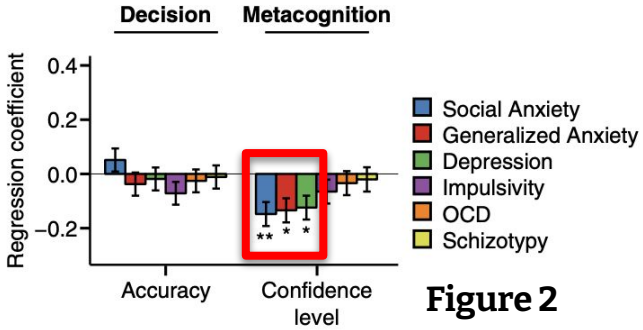


Figure 2

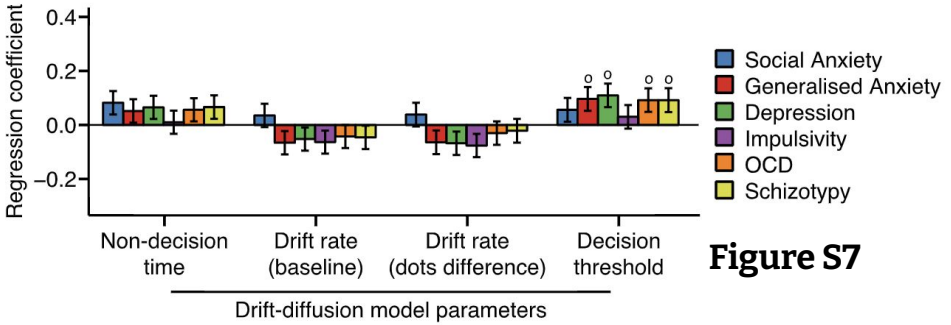


Figure S7

Experiment 2

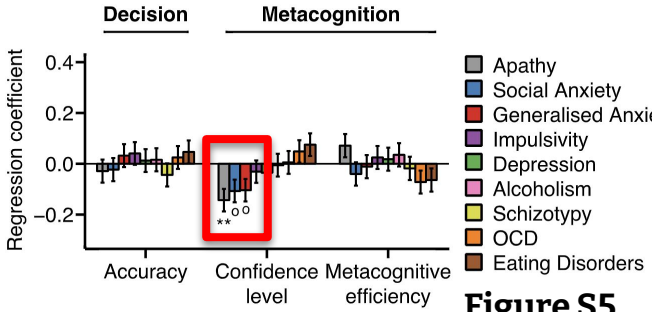


Figure S5

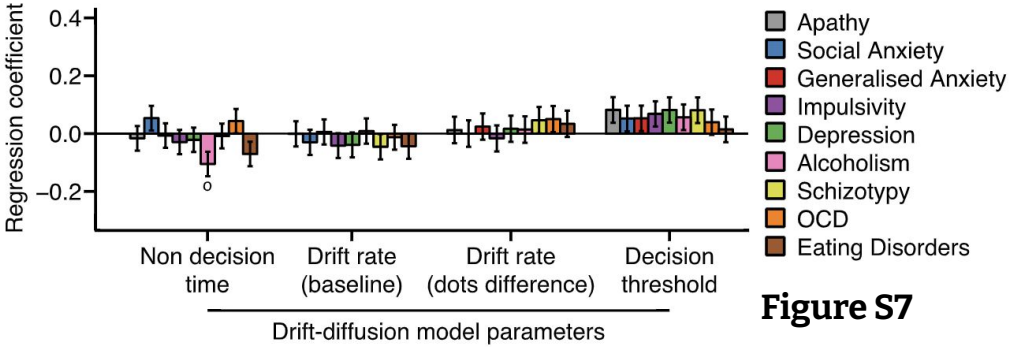


Figure S7

Results

Decision & Metacognition – Psychopathology

Experiment 2

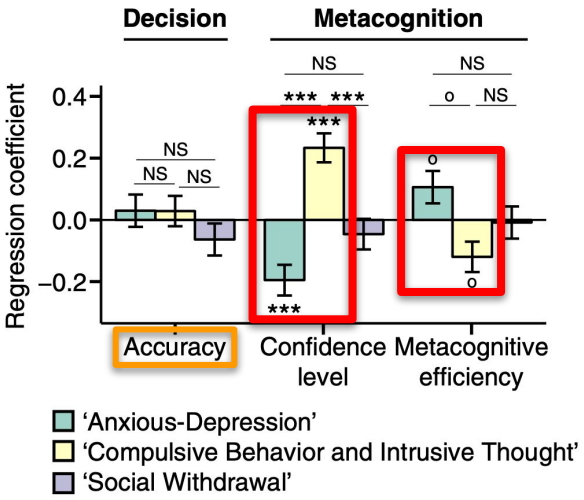


Figure 4

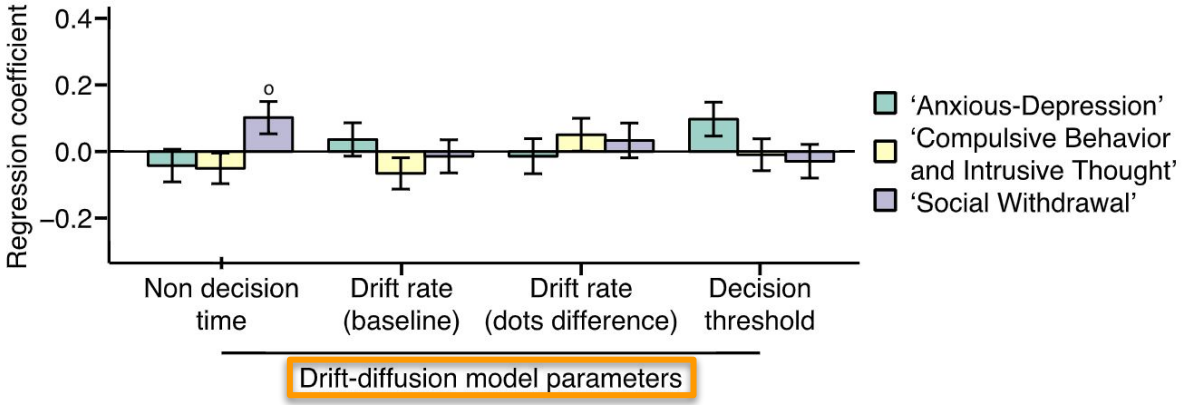


Figure S7

Model comparison

Experiment 2

Variables list:
Accuracy
Non-decision time
Drift rate (baseline)
Drift rate (dots difference)
Decision threshold
Confidence level
Metacognitive efficiency

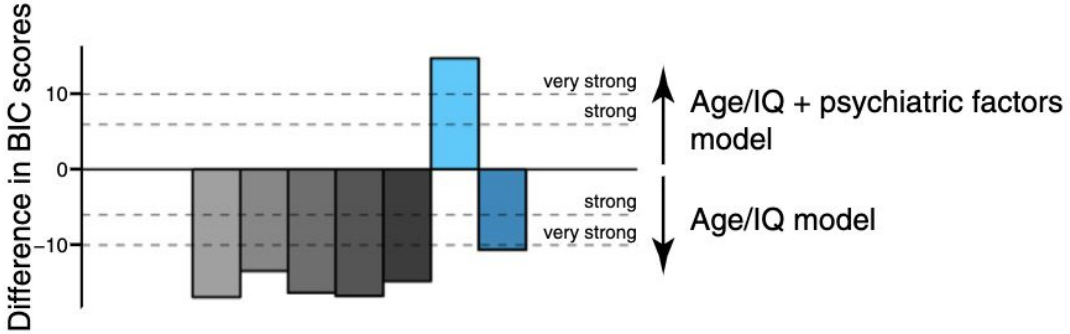


Figure 5

Discussion

- Anxious-Depression (AD)
  - ⬇️ confidence level & ⬆️ higher metacognitive efficiency
- Compulsive-Behavior and Intrusive Thought (CIT)
  - ⬆️confidence level & ⬇️ metacognitive efficiency
- Systematic trait-level differences in metacognitive computation among individuals, reflecting a component of transdiagnostic psychopathology
- Complicated relationship between metacognition and decision performance
- Limitations: web-based experiment

References

- Rouault, M., Seow, T., Gillan, C. M., & Fleming, S. M. (2018). Psychiatric symptom dimensions are associated with dissociable shifts in metacognition but not task performance. *Biological psychiatry*, *84*(6), 443-451.
- Wiecki, T. V., Poland, J., & Frank, M. J. (2015). Model-based cognitive neuroscience approaches to computational psychiatry: clustering and classification. *Clinical Psychological Science*, *3*(3), 378-399.
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- Fleming, S. M. (2017). HMeta-d: hierarchical Bayesian estimation of metacognitive efficiency from confidence ratings. *Neuroscience of consciousness*, *2017*(1), nix007.
- Gillan, C. M., Kosinski, M., Whelan, R., Phelps, E. A., & Daw, N. D. (2016). Characterizing a psychiatric symptom dimension related to deficits in goal-directed control. Elife, 5, e11305.

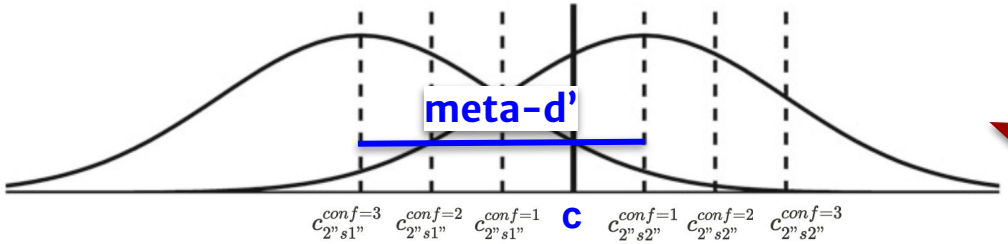
Thanks!

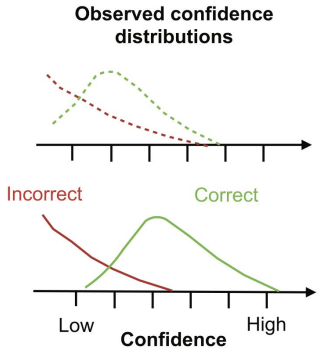
Methods

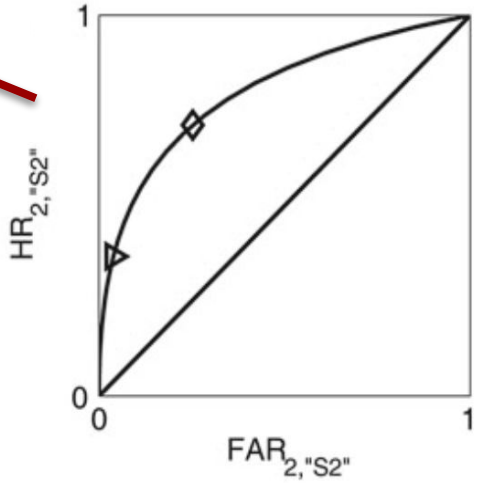
Models and Analyses

Type 2 SDT (meta-SDT)

Experiment 1	Experiment 2
Drift-Diffusion Model	
	Type 2 SDT
	Factor Analysis







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Fleming, S. M. (2017)

Age/IQ – Decision formation & Metacognition

Experiment 1

Experiment 2

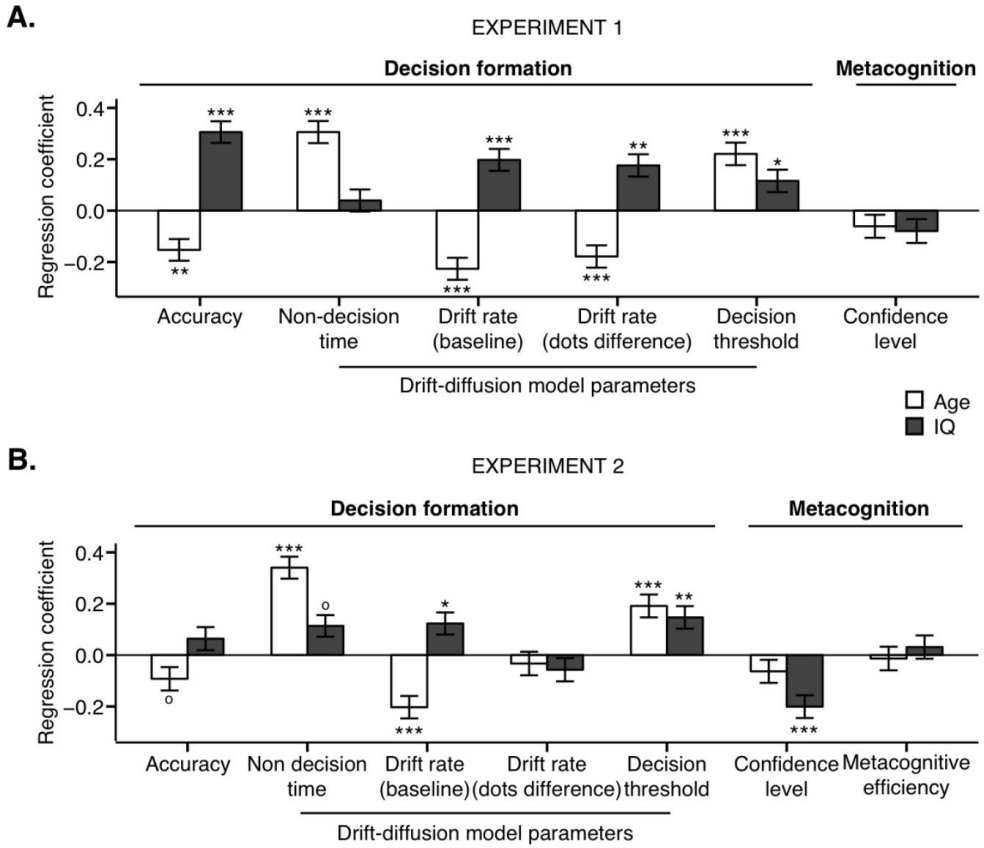

Figure S6

Results

Decision & Metacognition – Psychopathology

Experiment 2

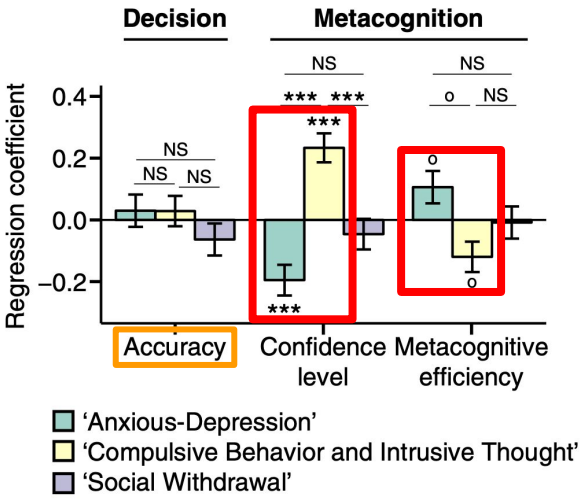

Figure 4

Not a trivial anticorrelation between AD and CIT scores.