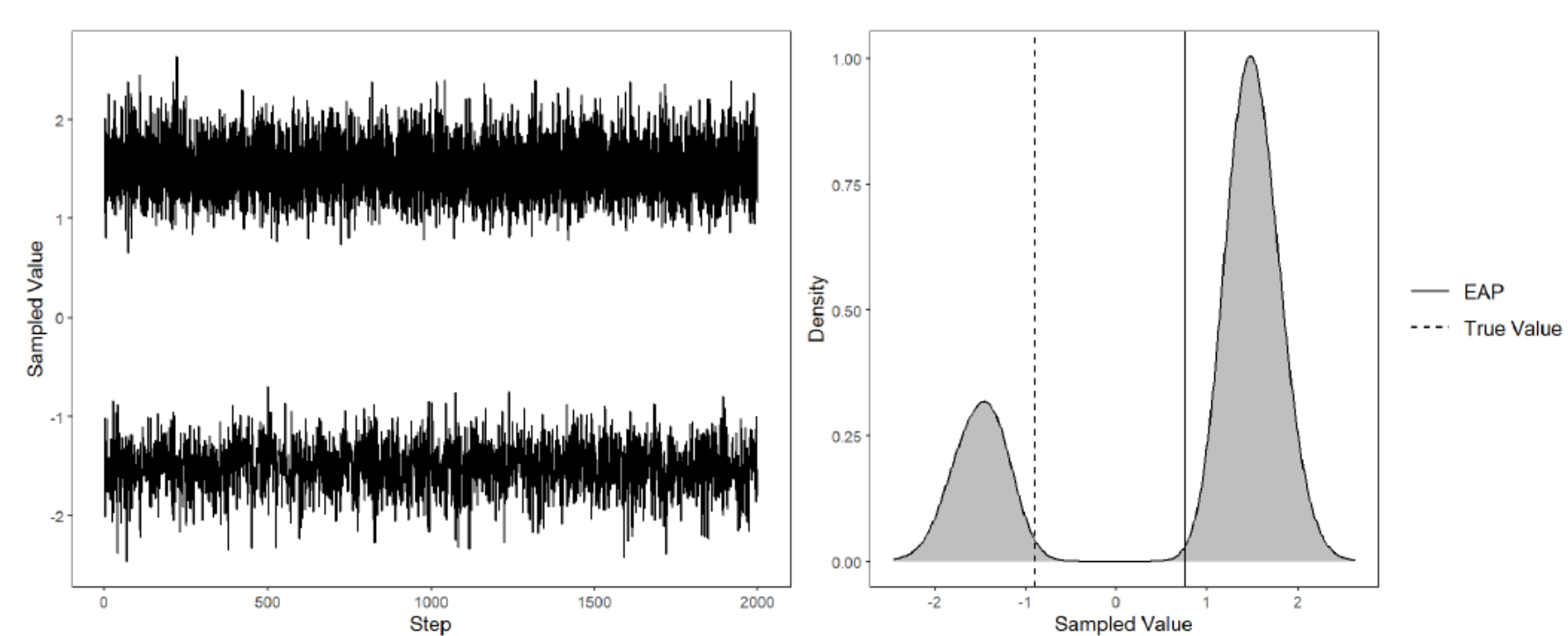


# Evaluating solutions to the label-switching issue when estimating latent variable models with the NUTS algorithm

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## Introduction

- Label switching: convergence of MCMC onto differing modes in posterior densities (Qiu & Yuan, 2023)
- Appears in Bayesian item response models that parameterize factor loadings ( $\lambda_i$ ) or item discrimination ( $\alpha_i$ )



## Methods

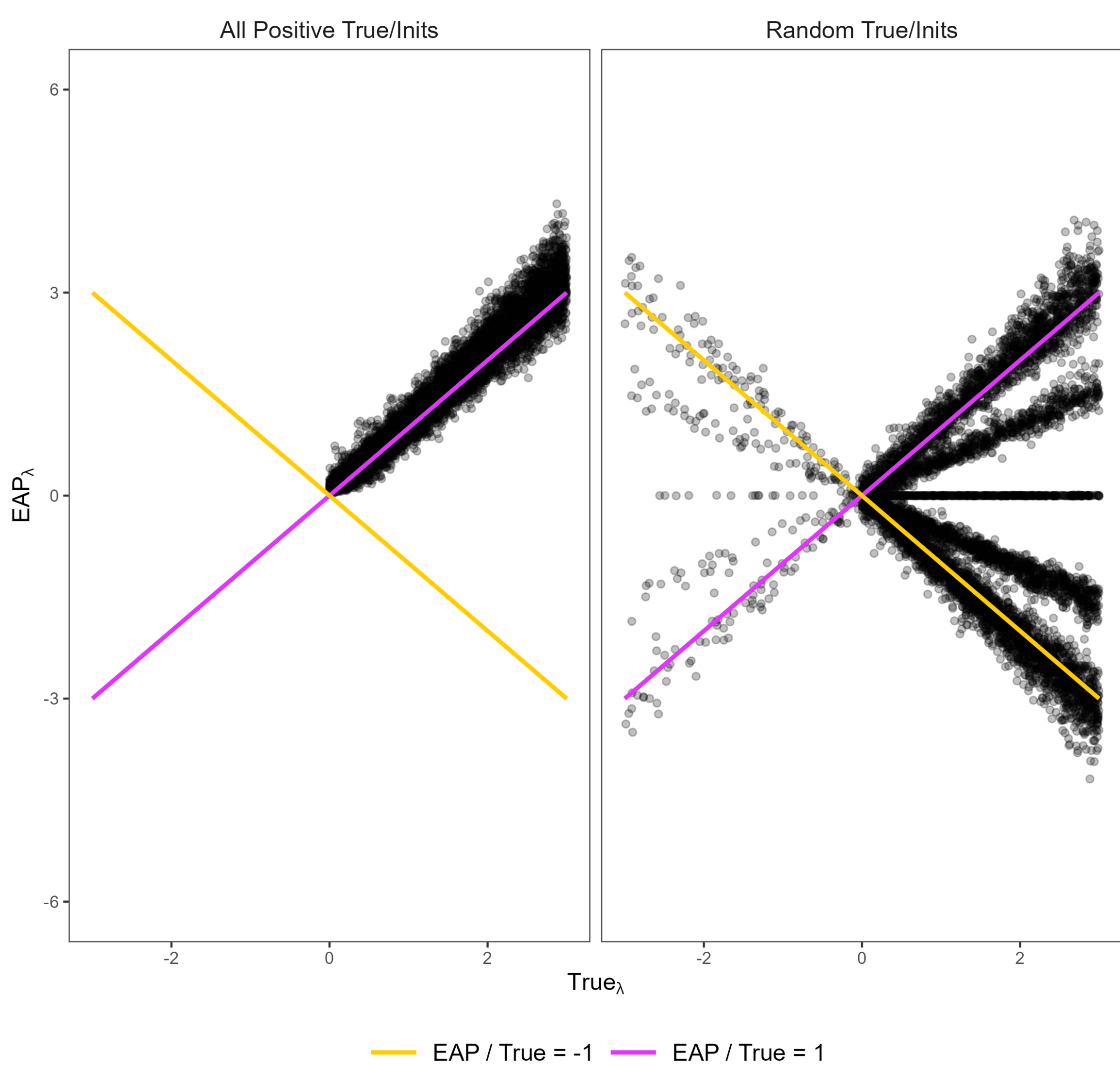
- Parameters sampled with the NUTS algorithm in Stan (Gabry, Češnovar, Johnson, & Bröder, 2024)
- Chain convergence determined using  $\hat{R} \leq 1.05$  (Vehtari et al., 2021)
- Parameter recovery performance evaluated using bias and RMSE estimates
- Each condition replicated 100 times in parallel using clusters within a High-performance computing environment

## References

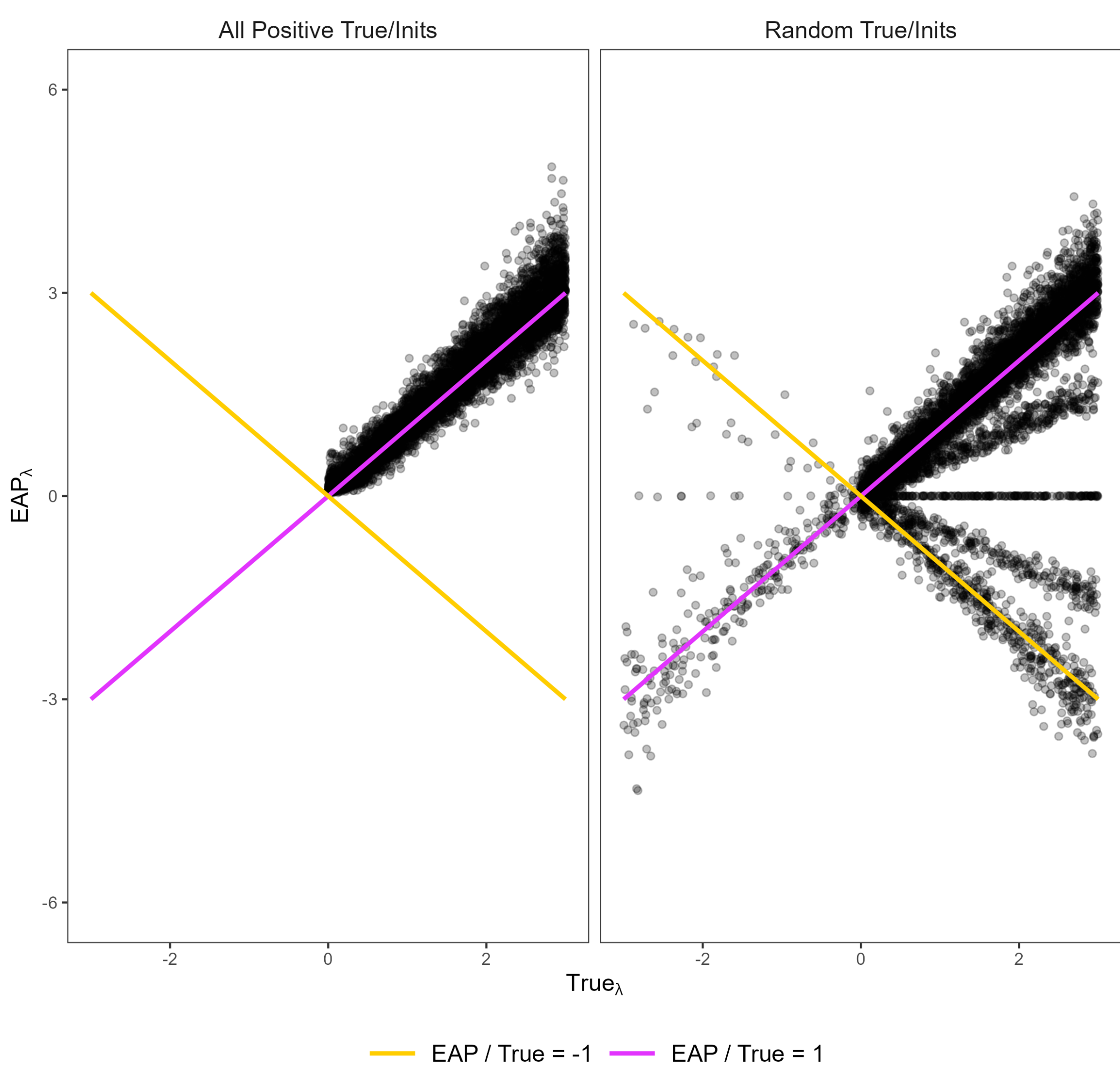


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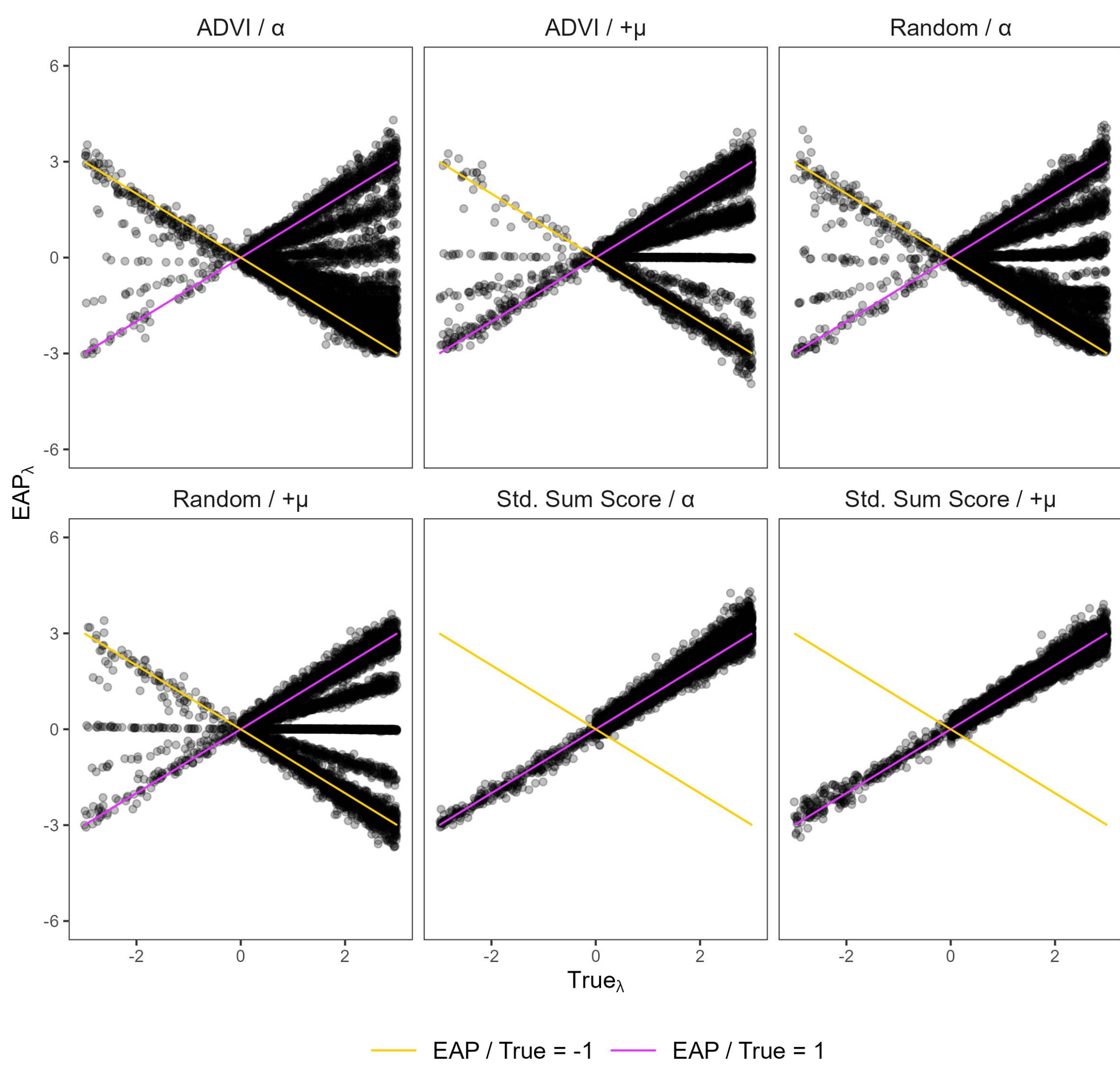
2PL Recovery: EAP  $\lambda$  vs. True  $\lambda$ , 500 Examinees (No Emp. Methods)



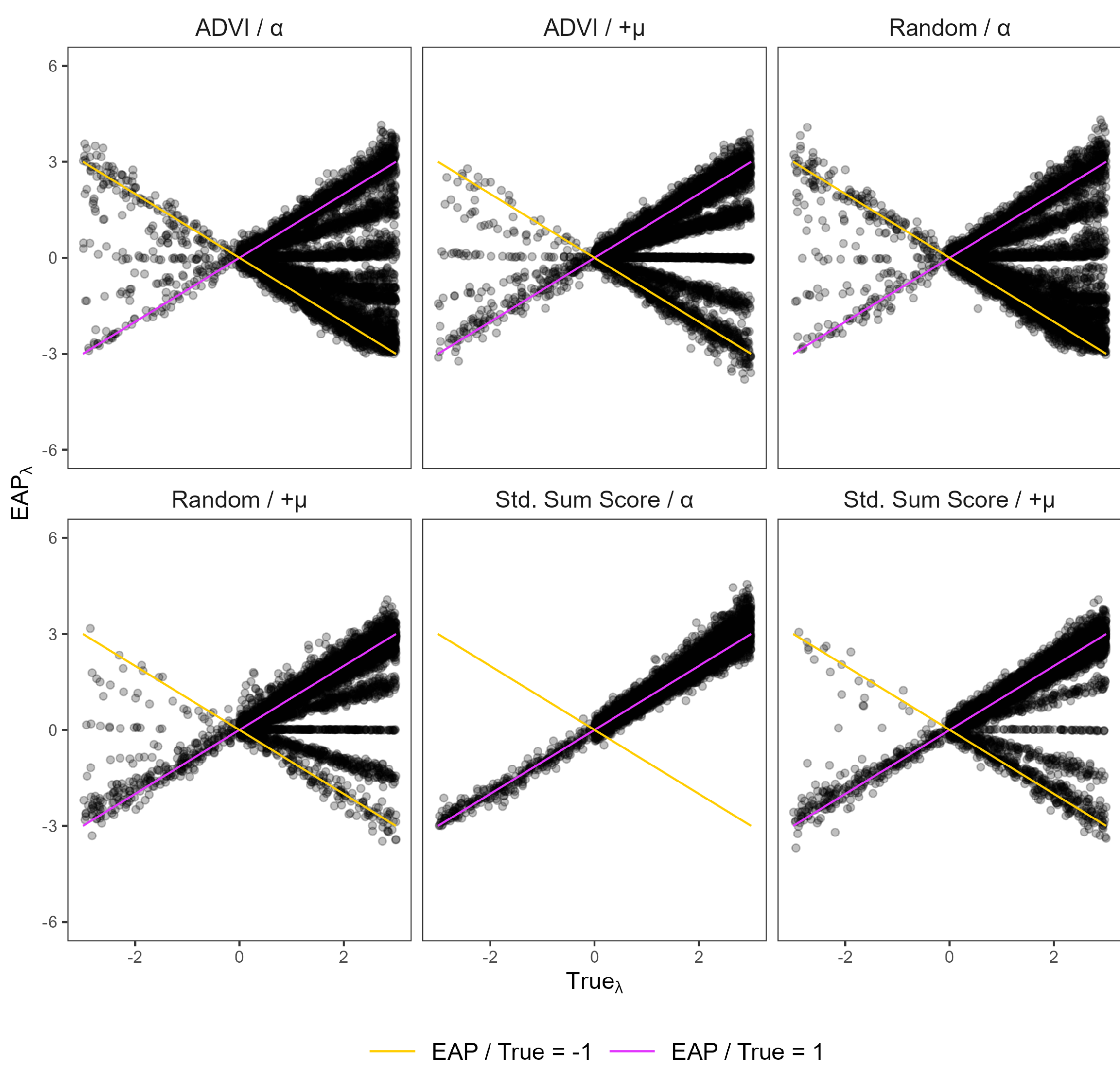
Bifactor Recovery: EAP  $\lambda$  vs. True  $\lambda$ , 500 Examinees (No Emp. Methods)



2PL Recovery: EAP  $\lambda$  vs. True  $\lambda$ , 500 Examinees (Init./Emp.)



Bifactor Recovery: EAP  $\lambda$  vs. True  $\lambda$ , 500 Examinees (Init./Emp.)



## Findings

2PL			
	Bias	RMSE	$N_{\hat{R}}$
All Positive True/Inits	0.114	0.256	0
Random True/Inits	-1.585	2.521	2595
ADVI / $\alpha$	-1.827	2.632	1553
ADVI / $+\mu$	-0.639	1.472	2135
Random/ $\alpha$	-1.514	2.386	1995
Random/ $+\mu$	-1.185	2.081	2517
Std. Sum Score/ $\alpha$	0.097	0.25	0
Std. Sum Score/ $+\mu$	0.018	0.201	0

Bifactor			
	Bias	RMSE	$N_{\hat{R}}$
All Positive True/Init.	0.016	0.163	712
All Random True/Init	-0.816	1.756	2252
ADVI / $\alpha$	-1.543	2.421	2847
ADVI / $+\mu$	-0.883	1.753	2572
Random/ $\alpha$	-1.525	2.422	1881
Random/ $+\mu$	-0.455	1.212	1929
Std. Sum Score/ $\alpha$	0.021	0.121	0
Std. Sum Score/ $+\mu$	-0.021	0.313	79

## Further Information

Scan the QR code below to access reproducible code, additional visualizations, and more on GitHub



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