

All Model Fits

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Introduction

This notebook reports coefficient plots, trace rank plots or “rank plots” (McElreath 2021), and posterior predictive checks for all models as well as some simple diagnostics (e.g., number of divergent transitions, if any).

The headers **give the model name** – e.g., RAG SELF INT refers to the main RAG SELF interaction model and RAG SELF ADD refers to the main RAG SELF additive model.

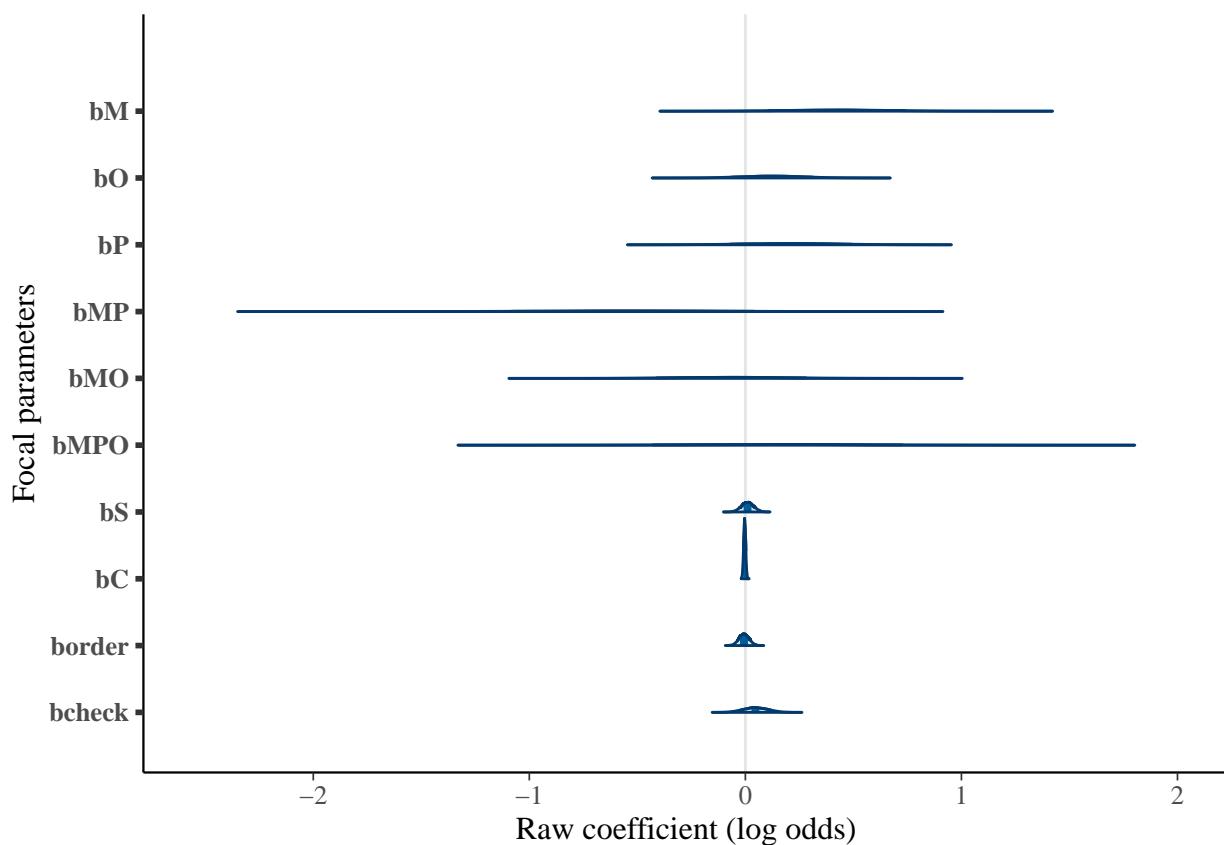
The **coefficient plots** report raw log odds for key parameters.

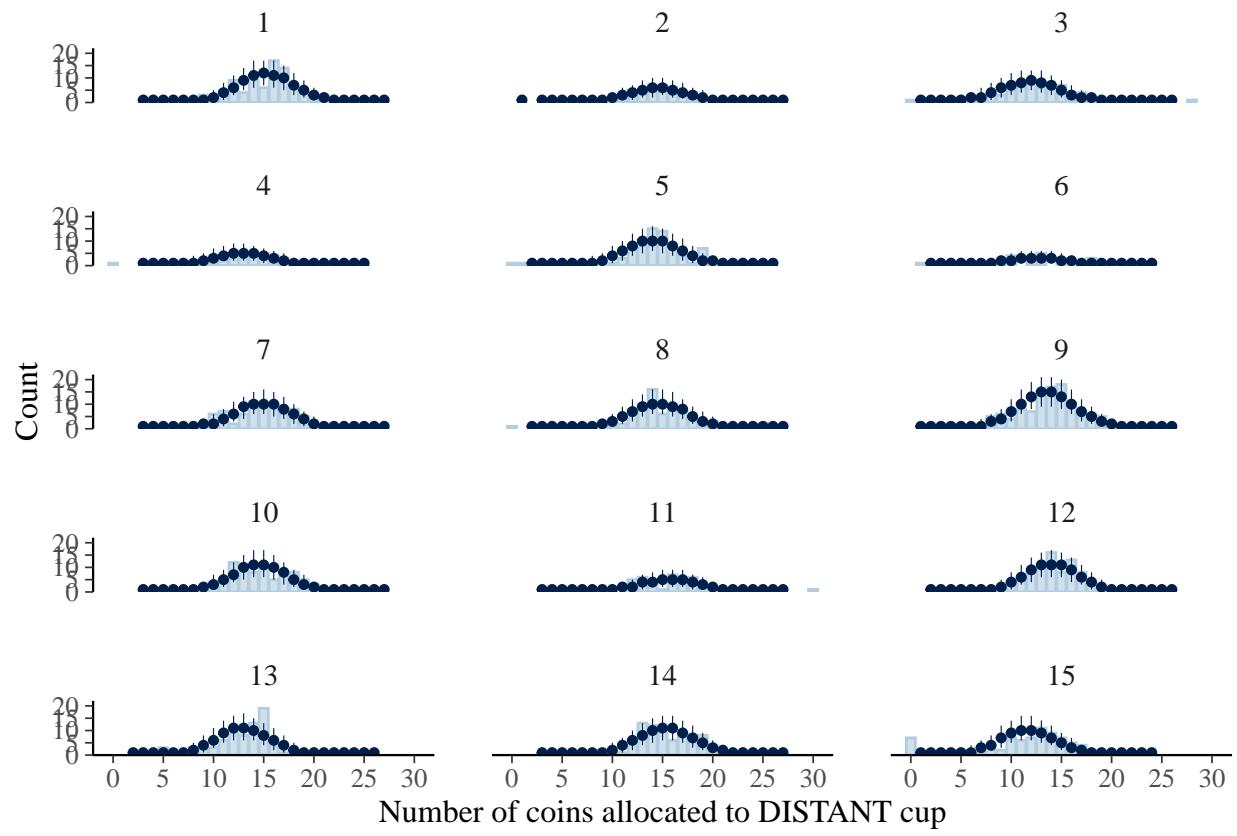
The **rank plots** display ranked histograms of each chain for key parameters; they are similar to the more conventional trace plots, in that for well-mixing chains we expect that no chain is consistently above or below the others (i.e., they are relatively uniform). The printed `n_eff` reports the effective number of samples from the posterior, where higher numbers indicate efficient chains. For each of four chains, we took 1000 warmup and 1000 post-warmup samples.

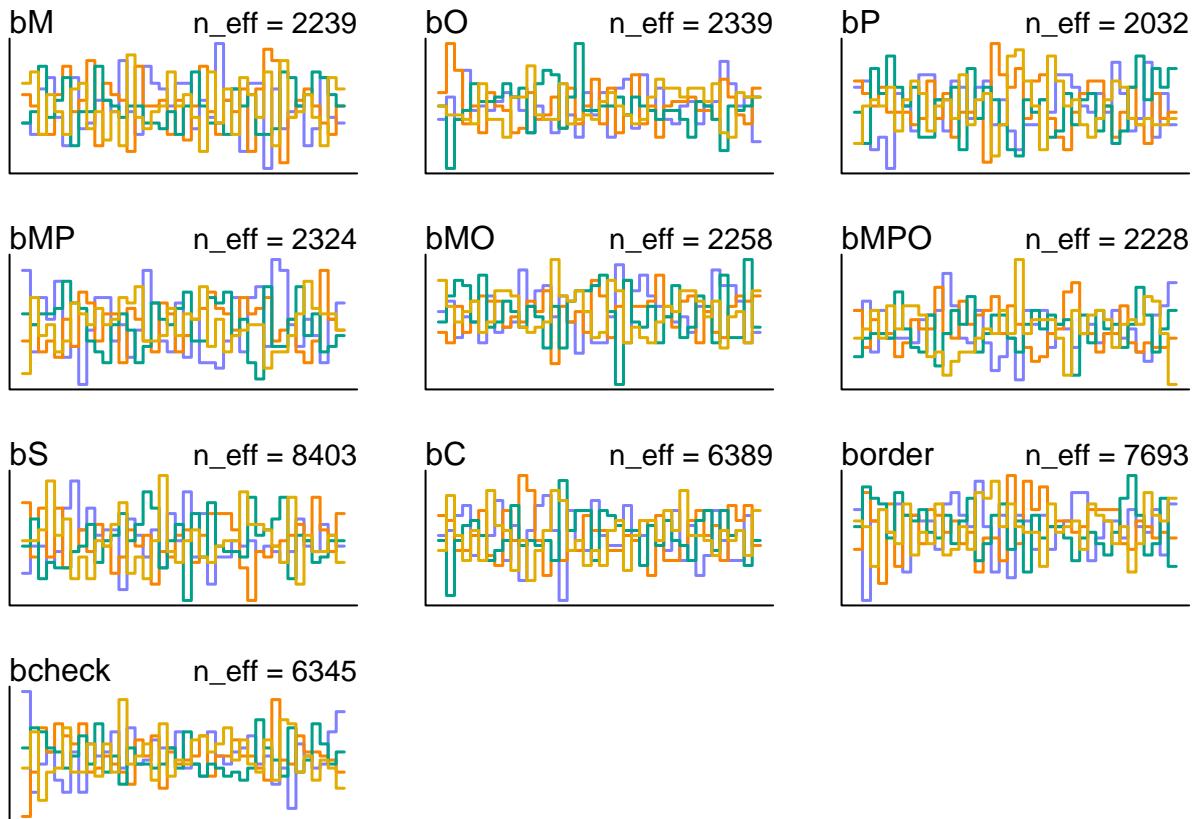
The **posterior predictive checks** give a sense of the models fit to the data; we generally expect posterior predictions (in dark blue lines and points) from a well-fitting model to resemble those of the original dataset (in light blue bars).

Below all additive models are printed **approximate LOO** model comparison metrics (difference in expected log posterior density (`elpd_diff`) and the standard error (`se_diff`) of the difference) for the interactive model (`model1`) and the additive model (`model2`) in each model pair. Generally speaking, the ELPD differences are small compared to their standard errors, indicating inconclusive evidence for interaction effects overall.

RAG SELF INT

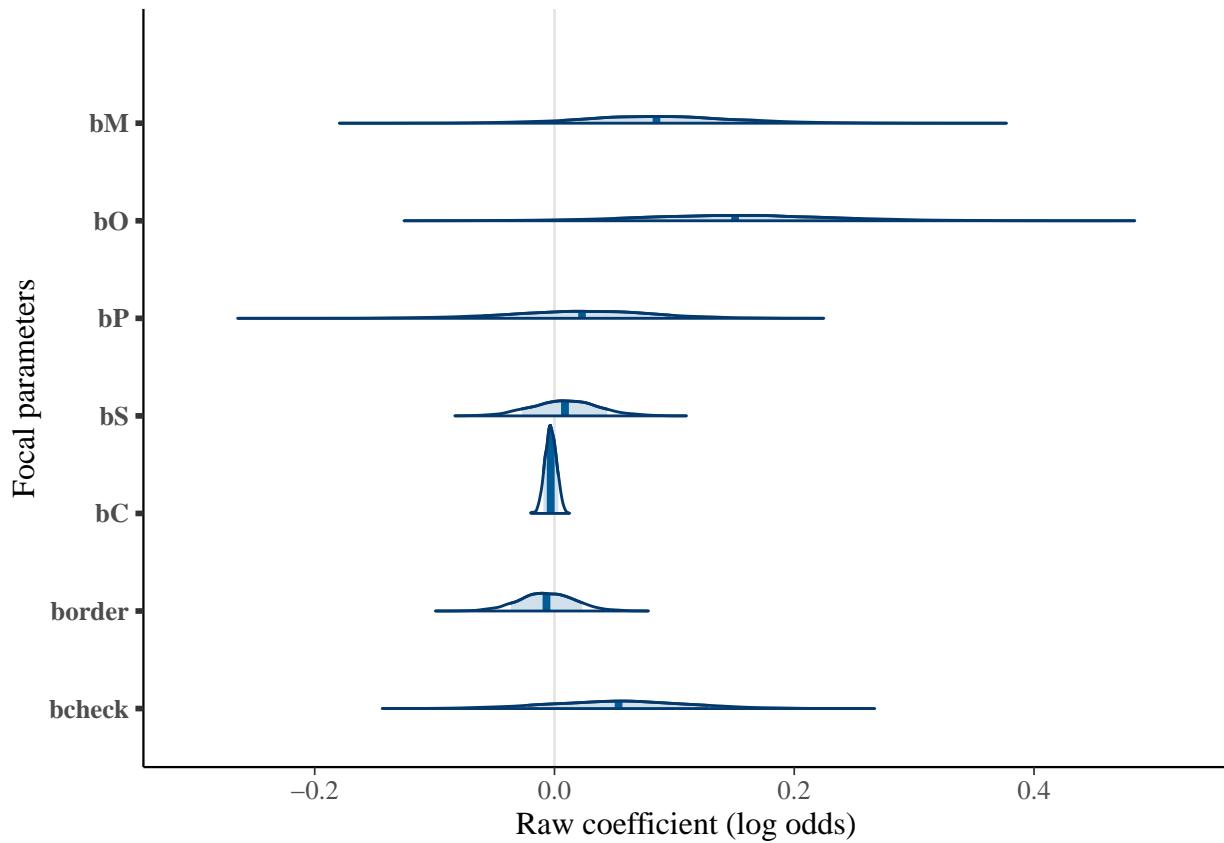


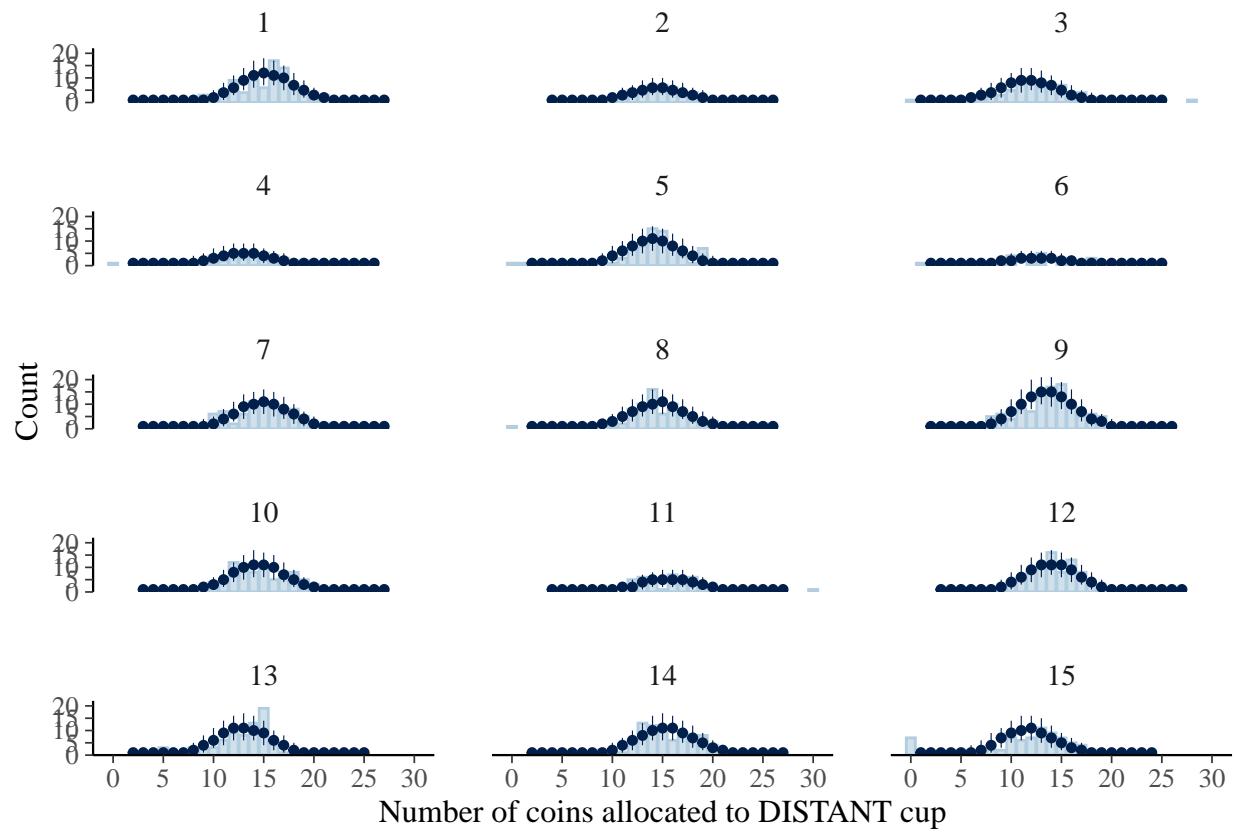


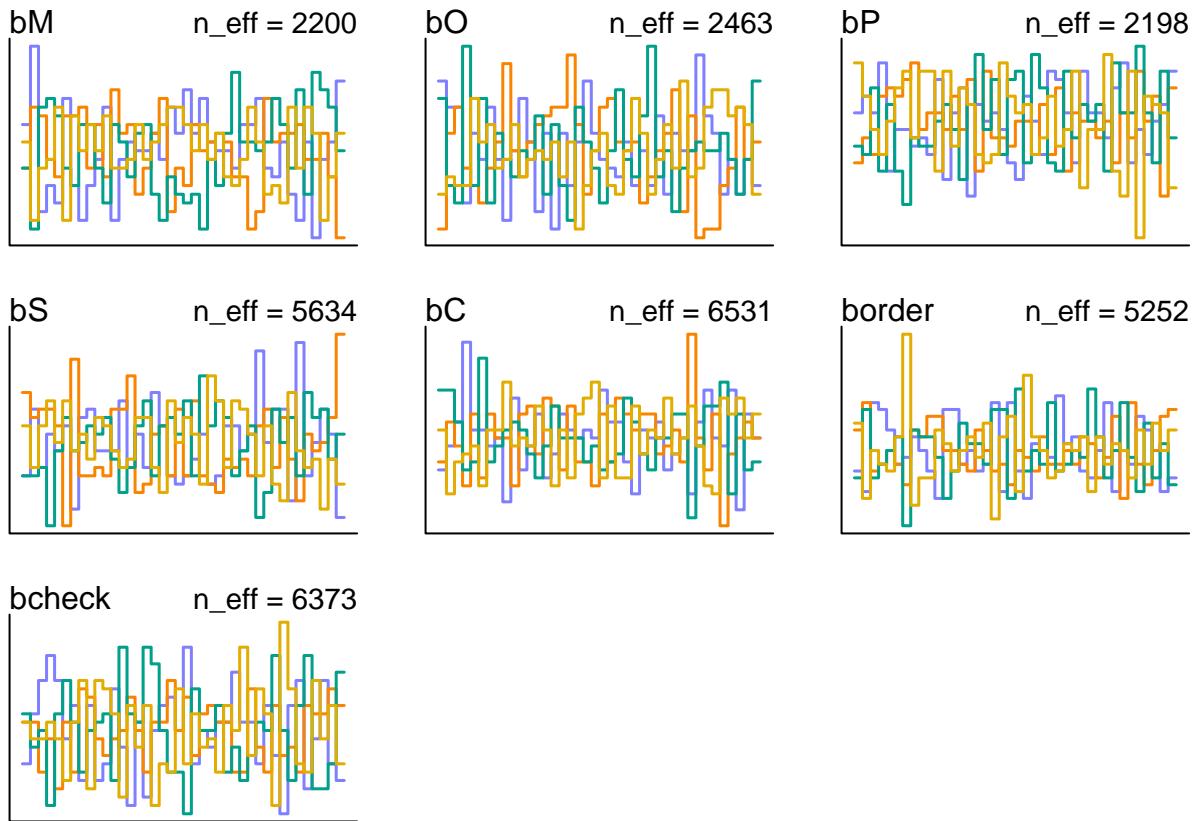


RAG SELF ADD

```
## Warning: 14 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```





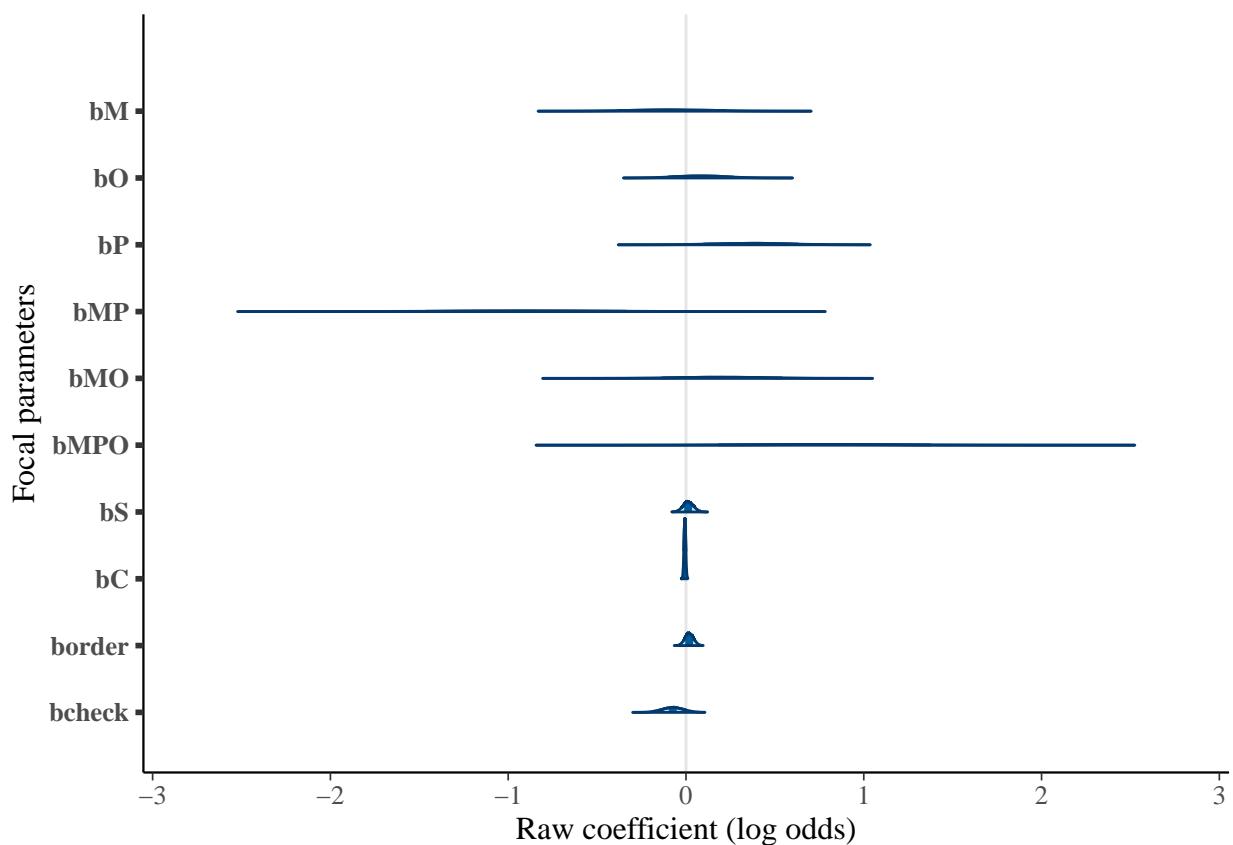


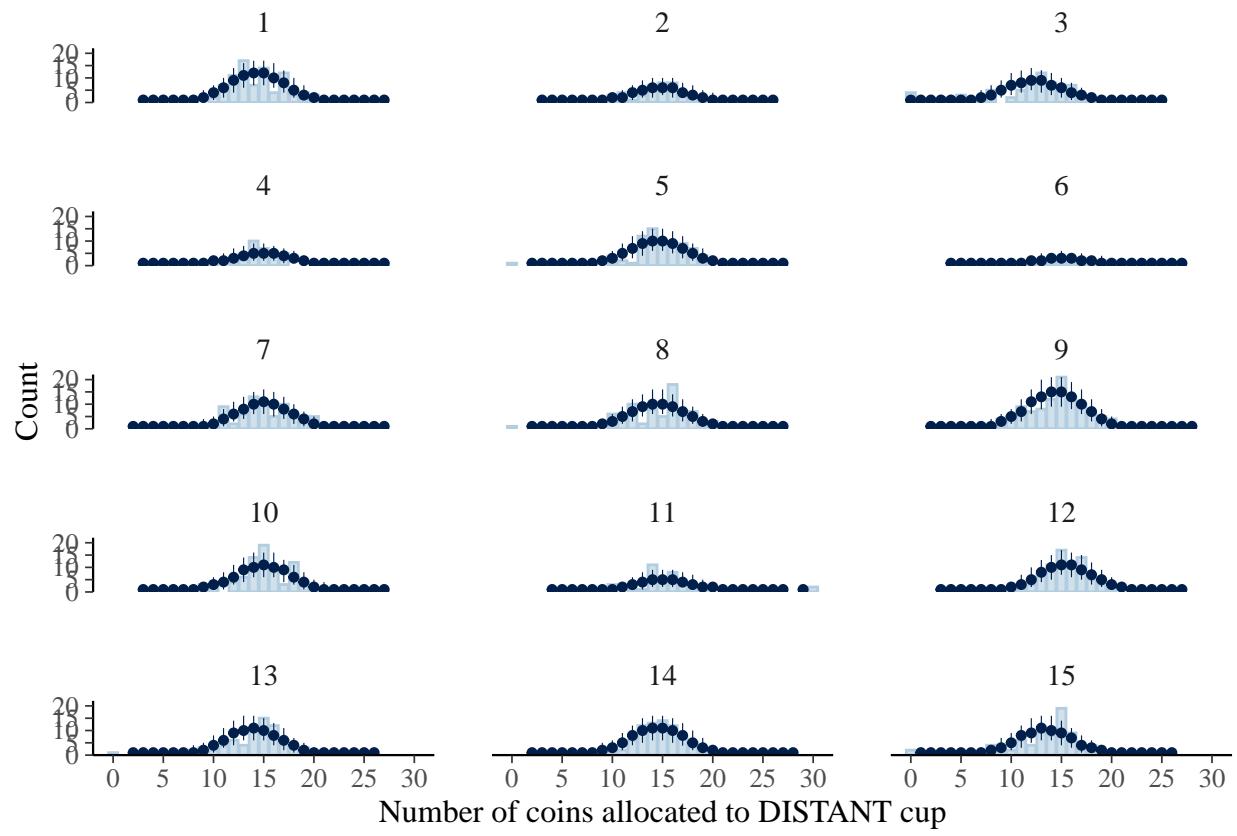
```

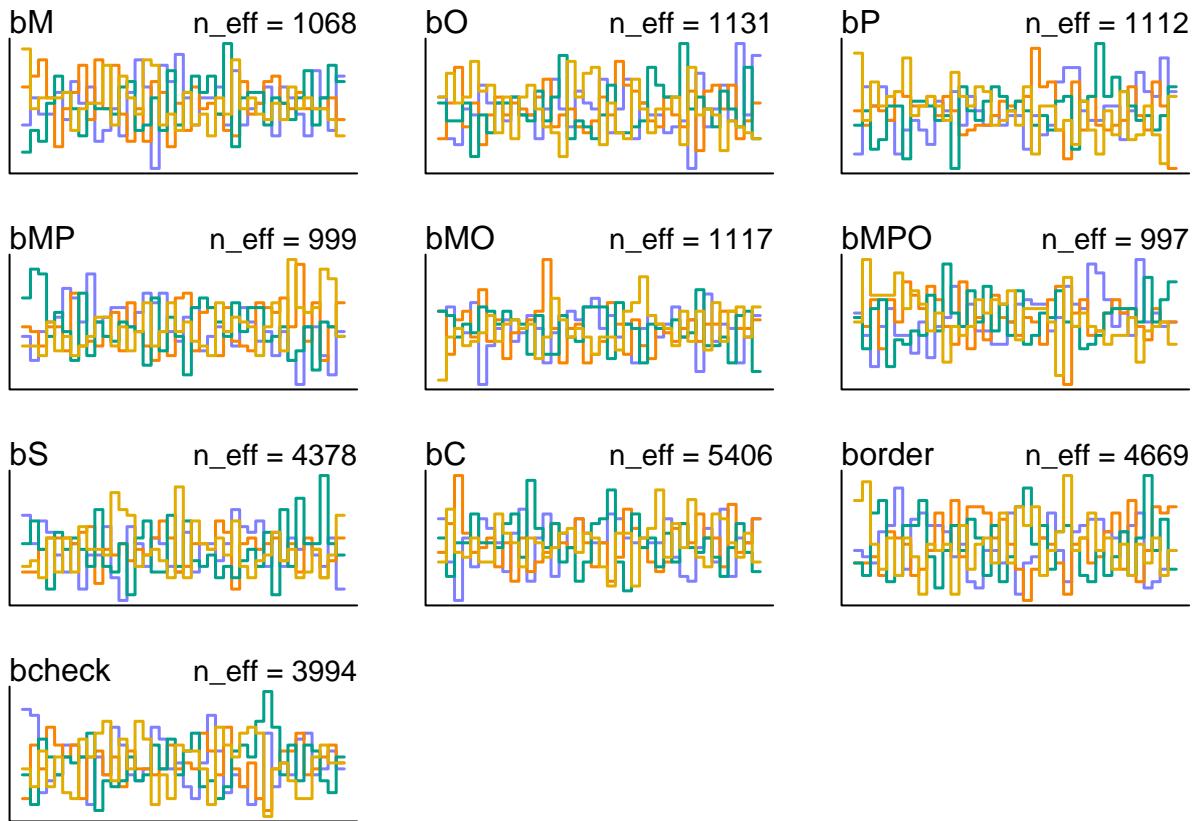
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -3.3     4.5

```

RAG LOCAL INT

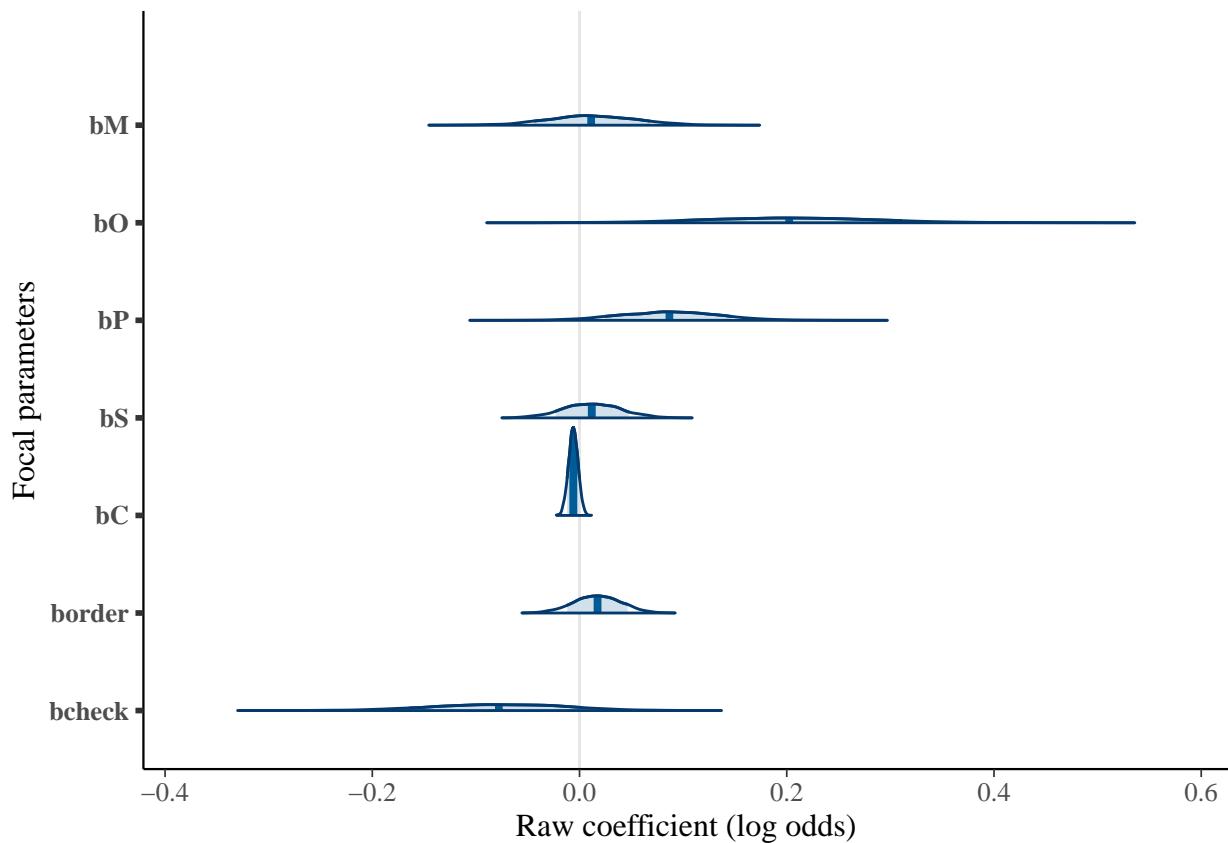


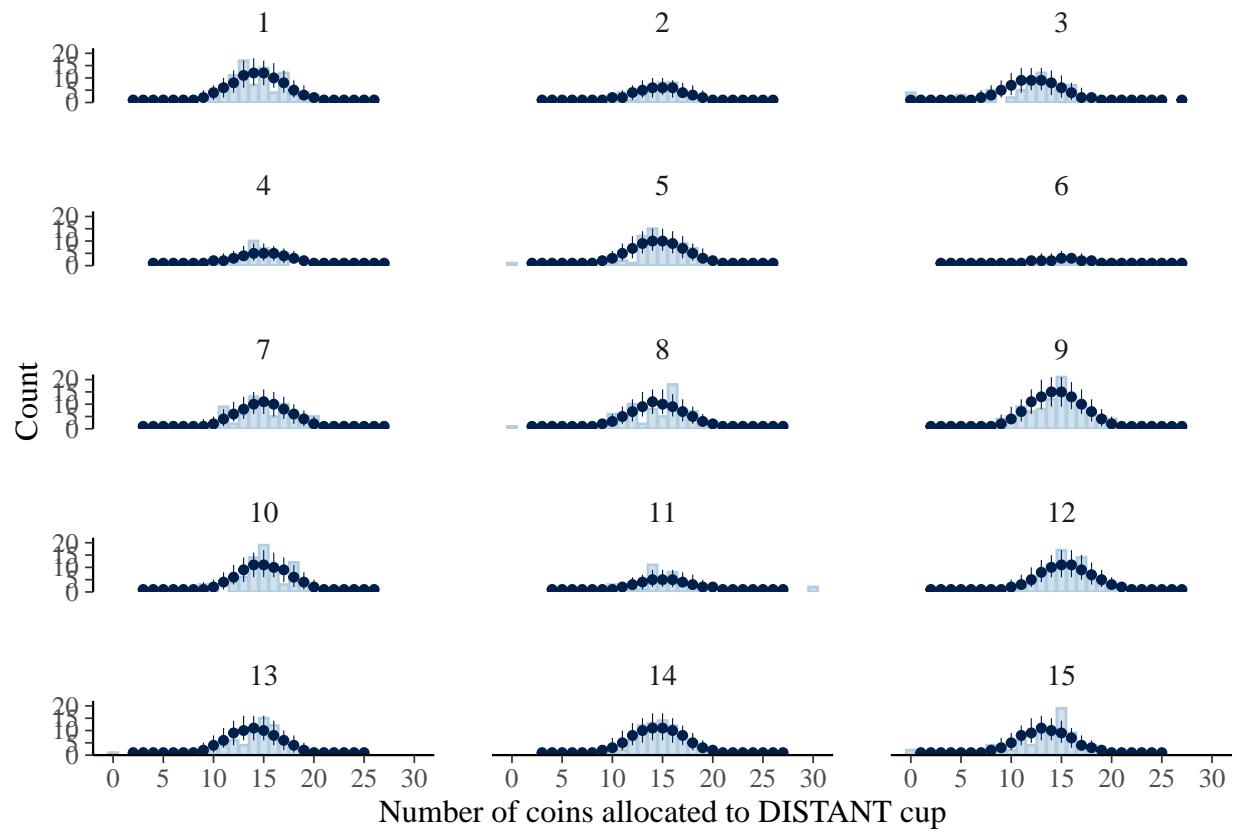


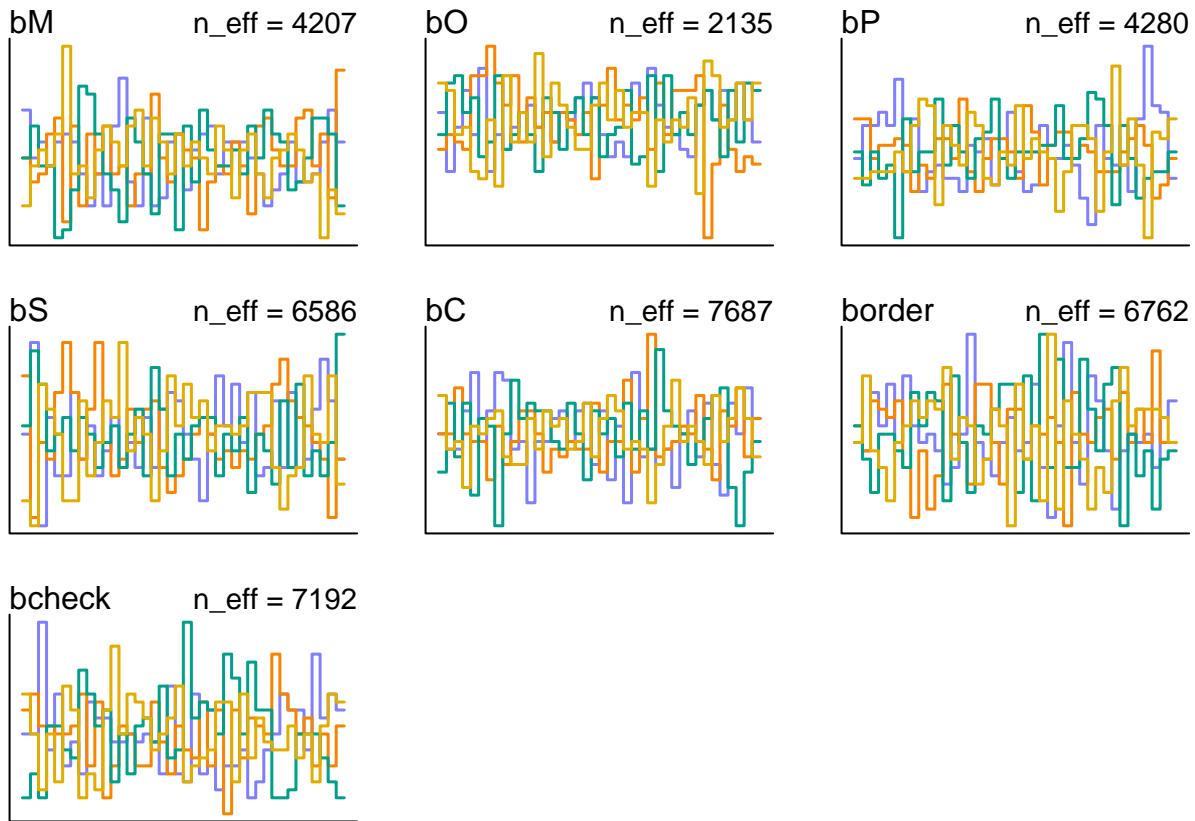


RAG LOCAL ADD

```
## Warning: 24 of 4000 (1.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```







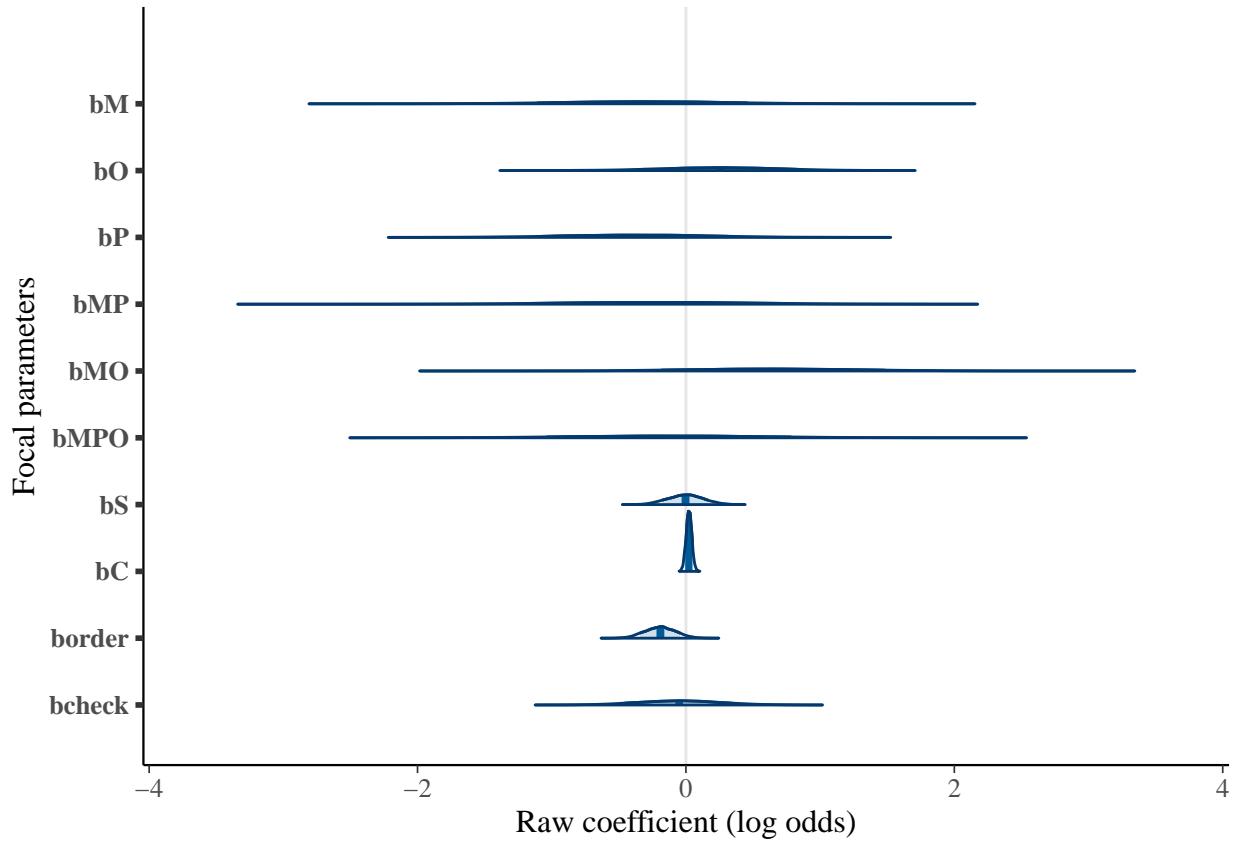
```

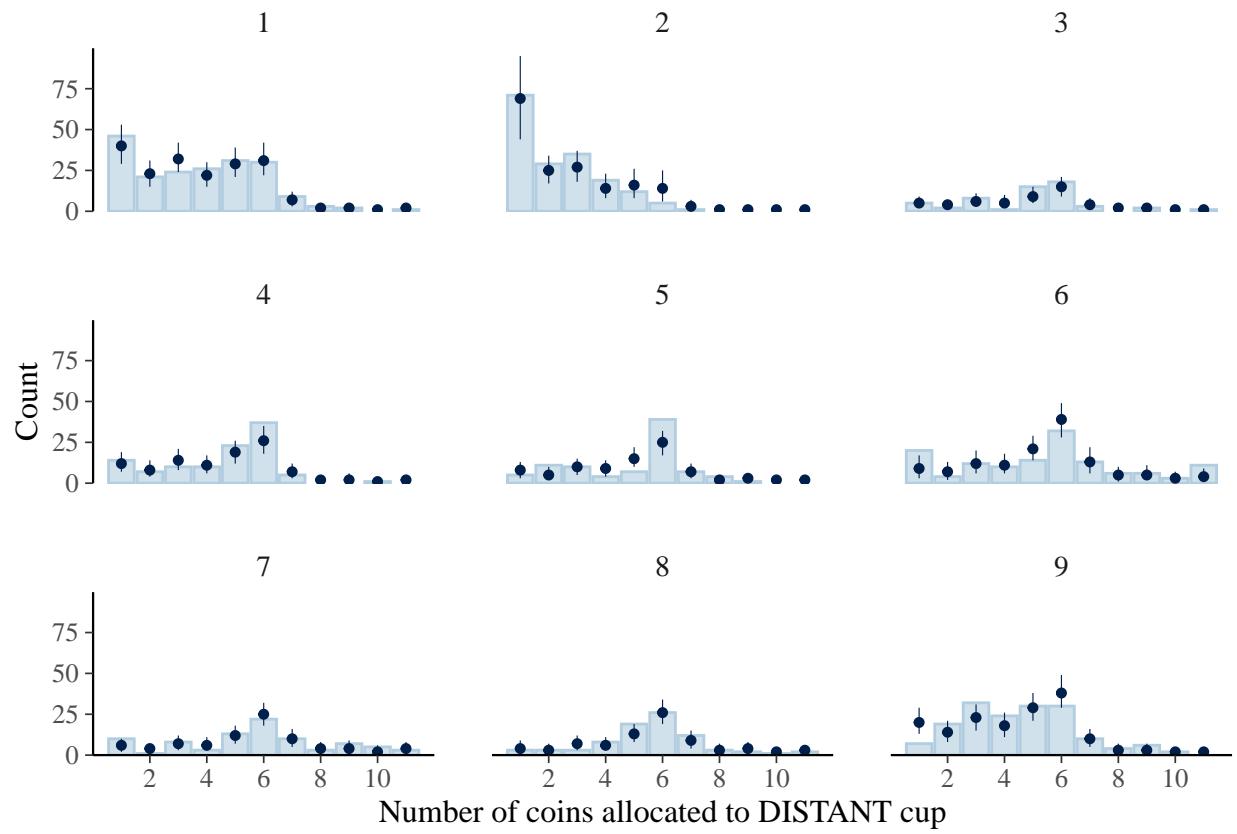
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -1.9     5.1

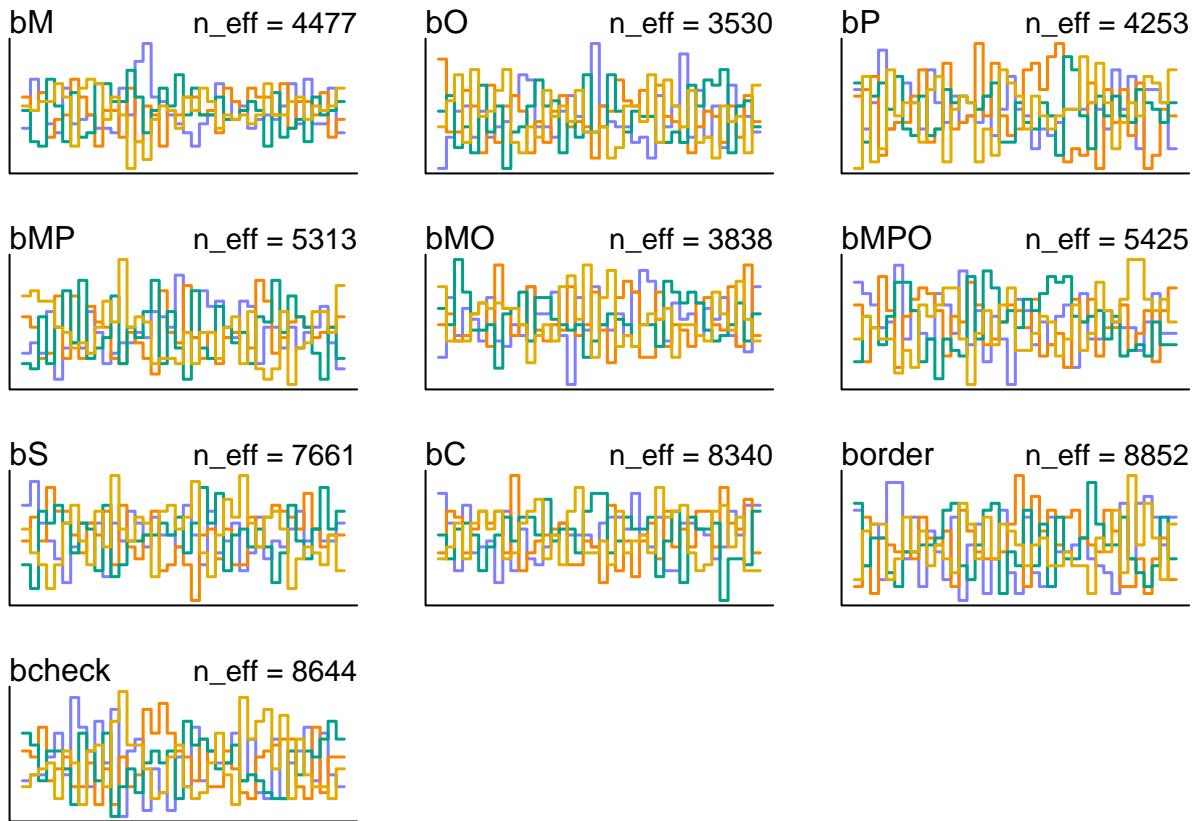
```

DG SELF INT

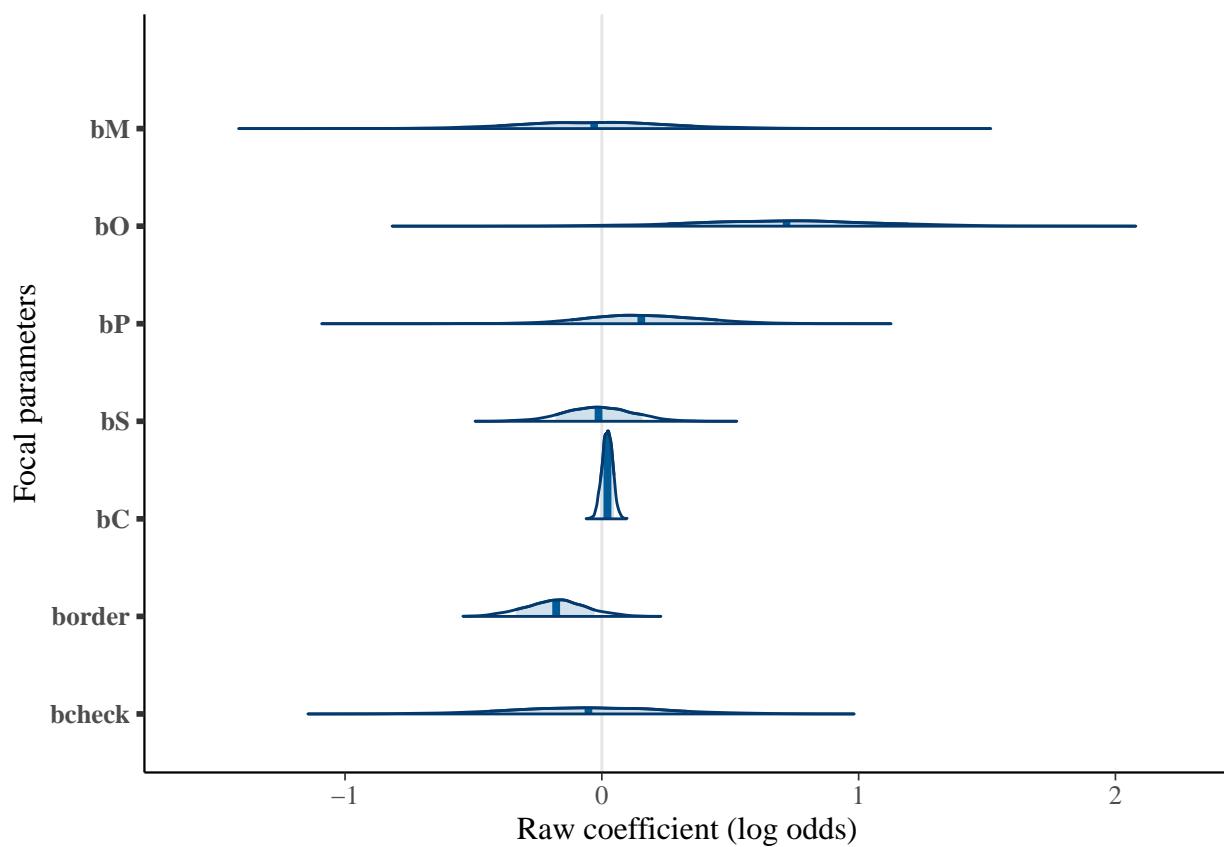
```
## Warning: 1 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```

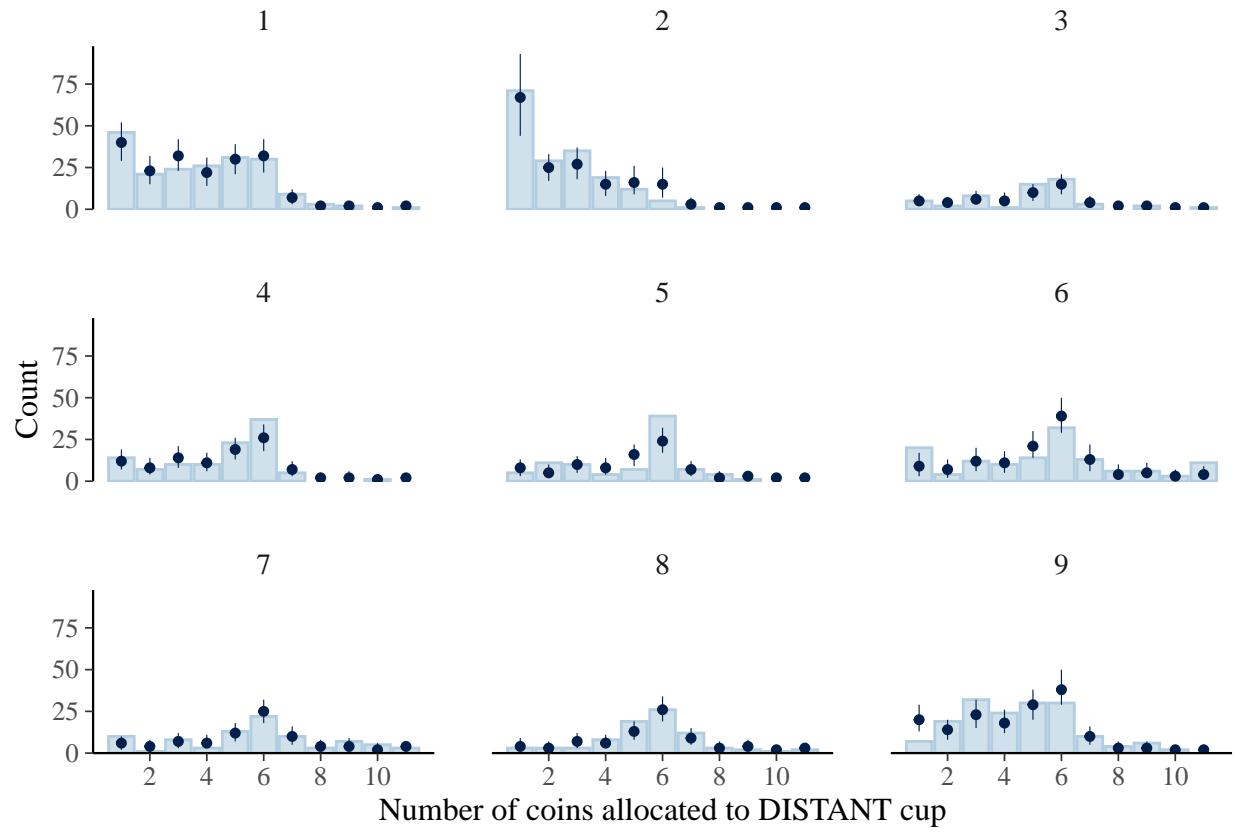


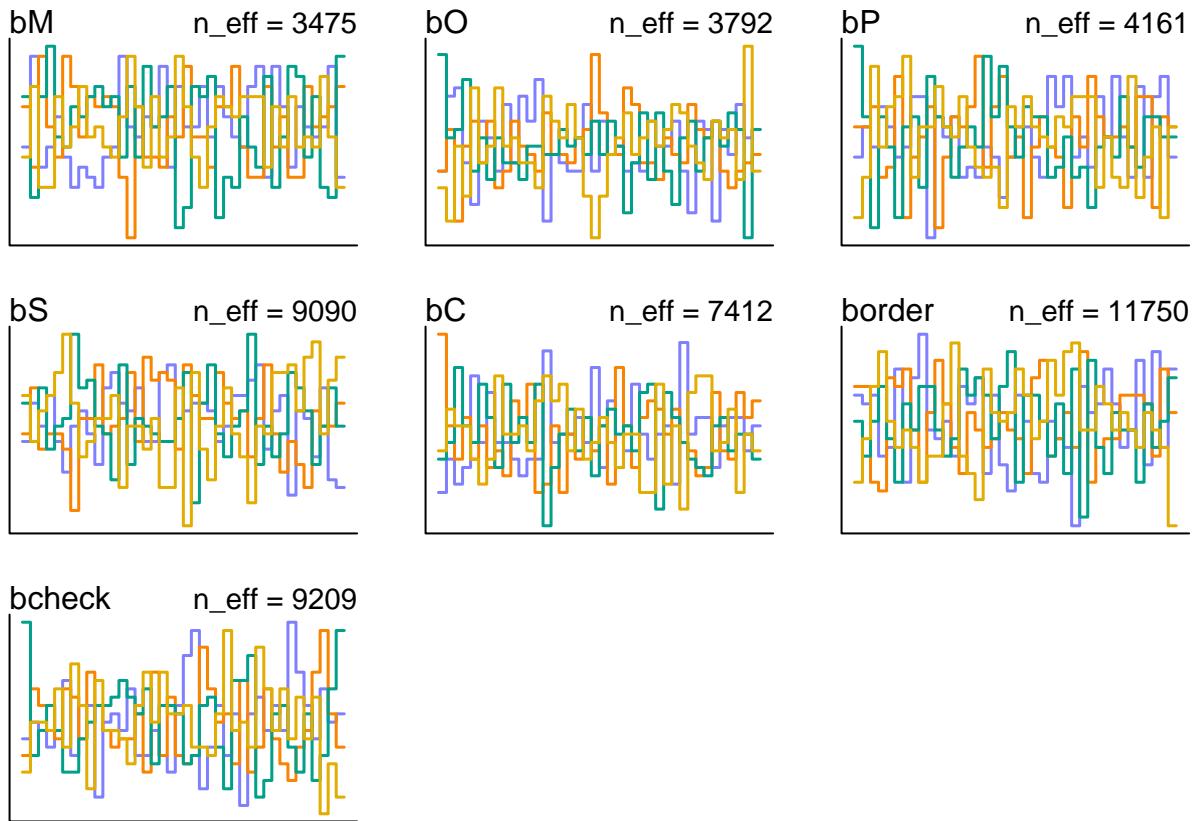




DG SELF ADD

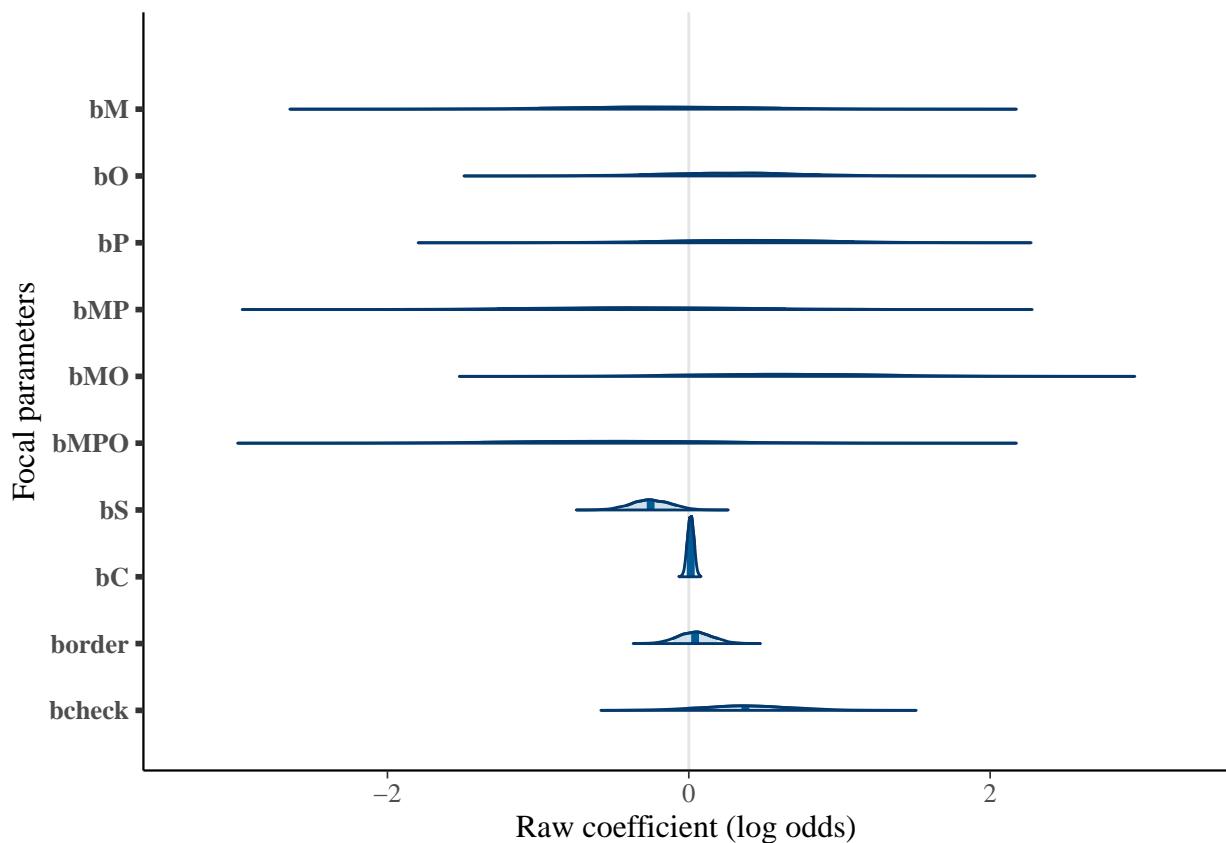


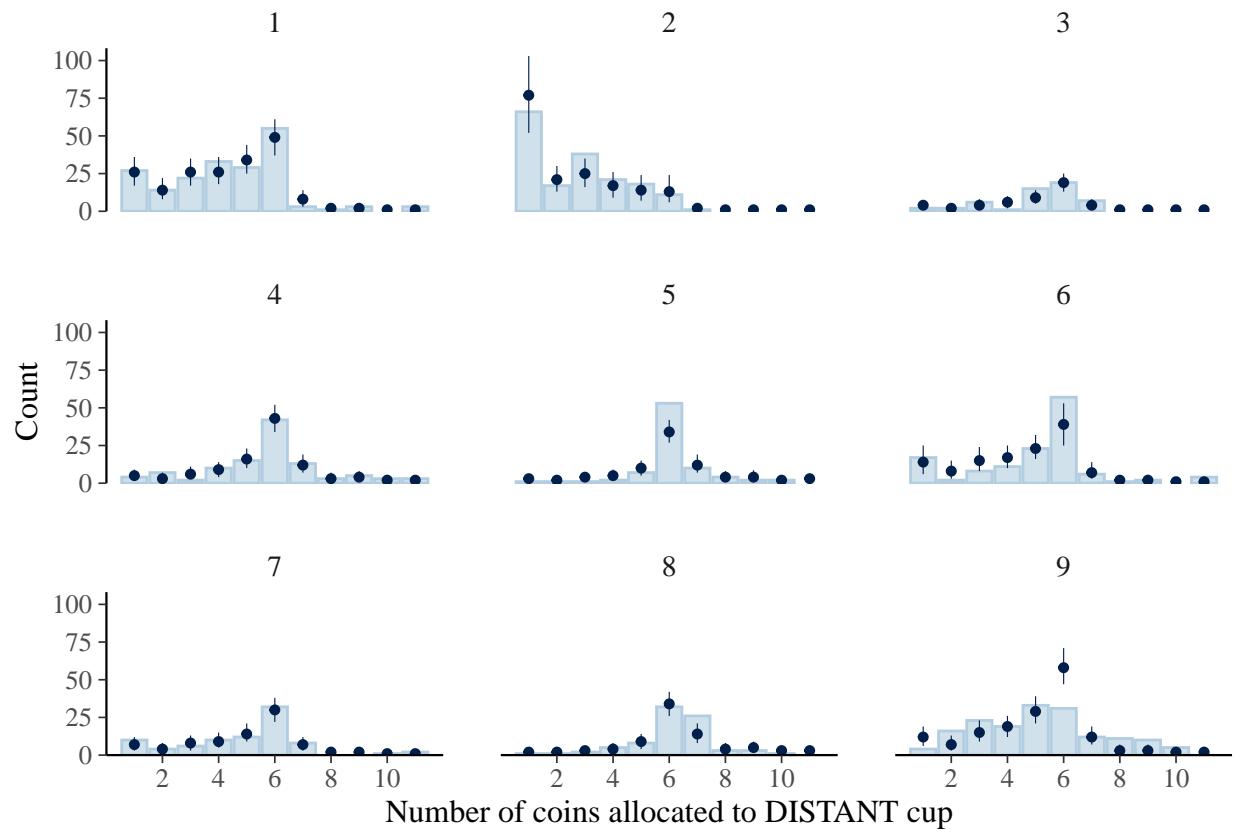


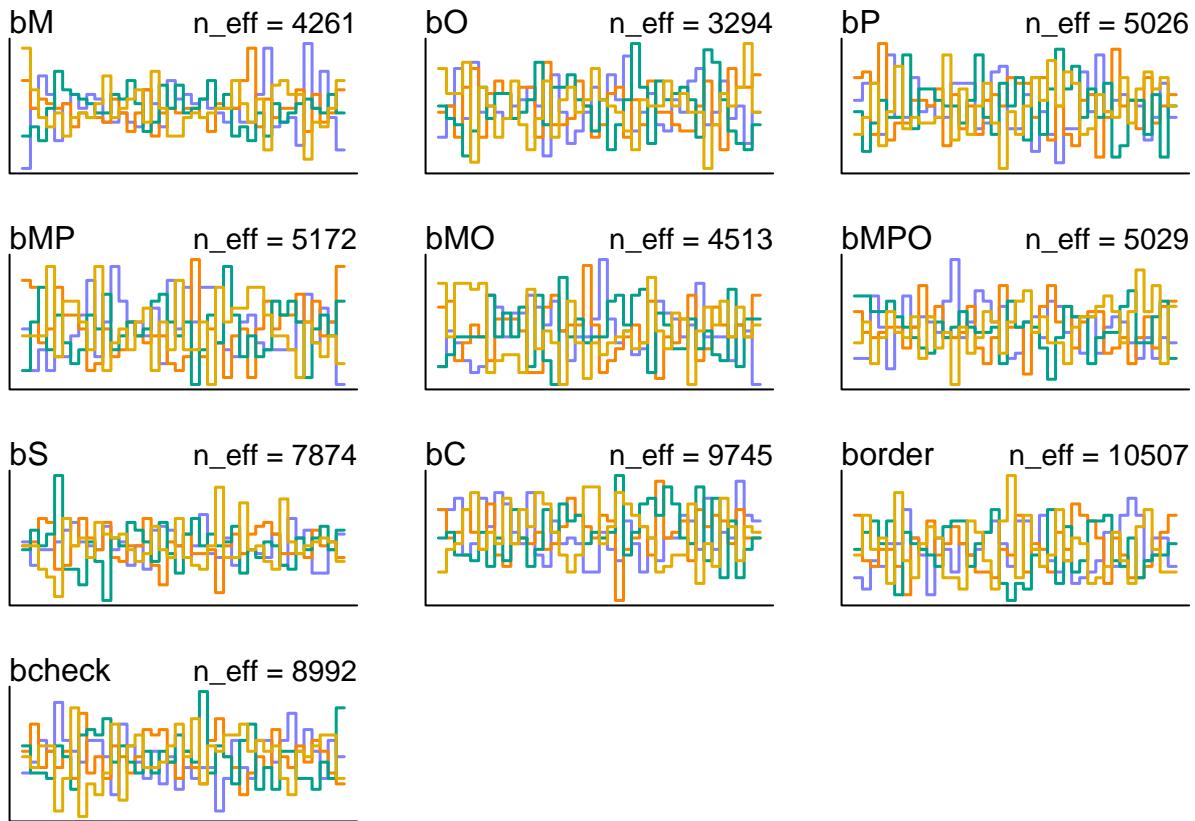


```
##           elpd_diff se_diff
## model2    0.0      0.0
## model1   -0.8     2.0
```

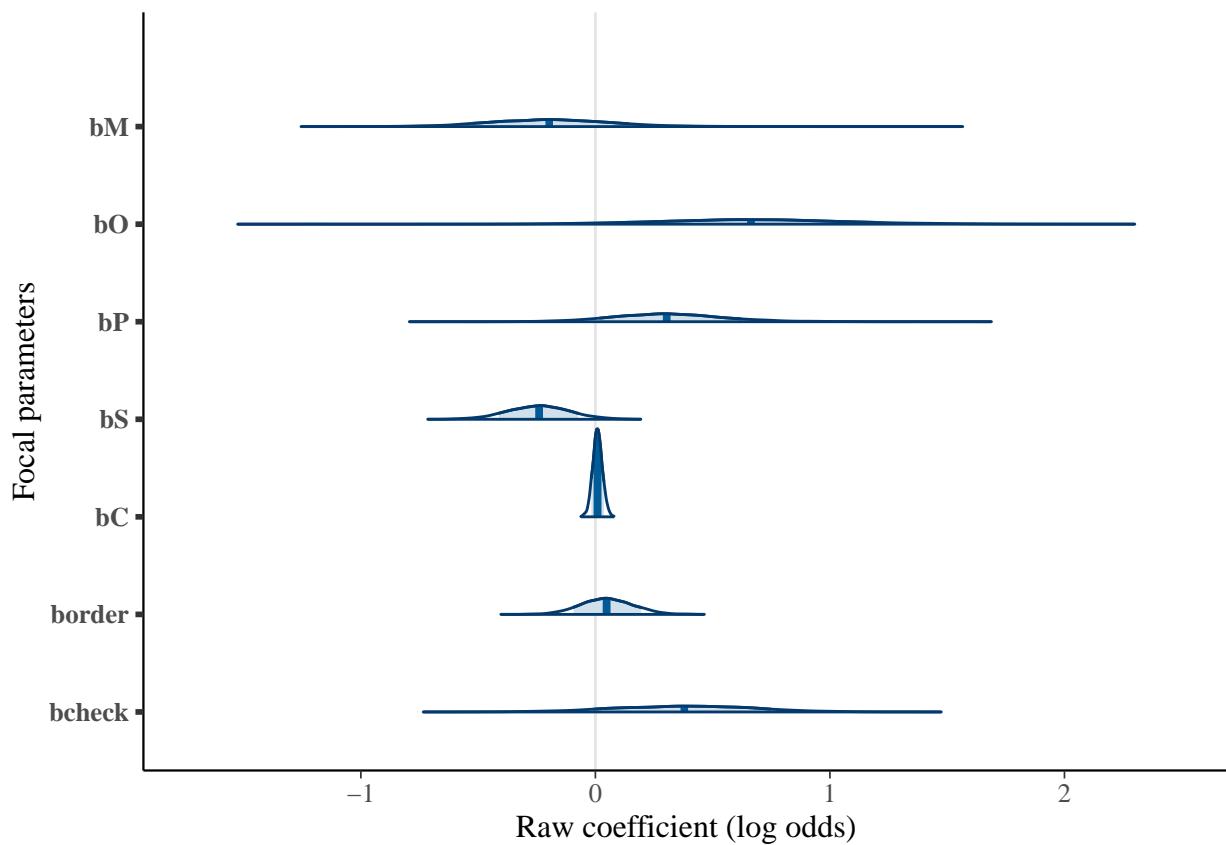
DG LOCAL INT

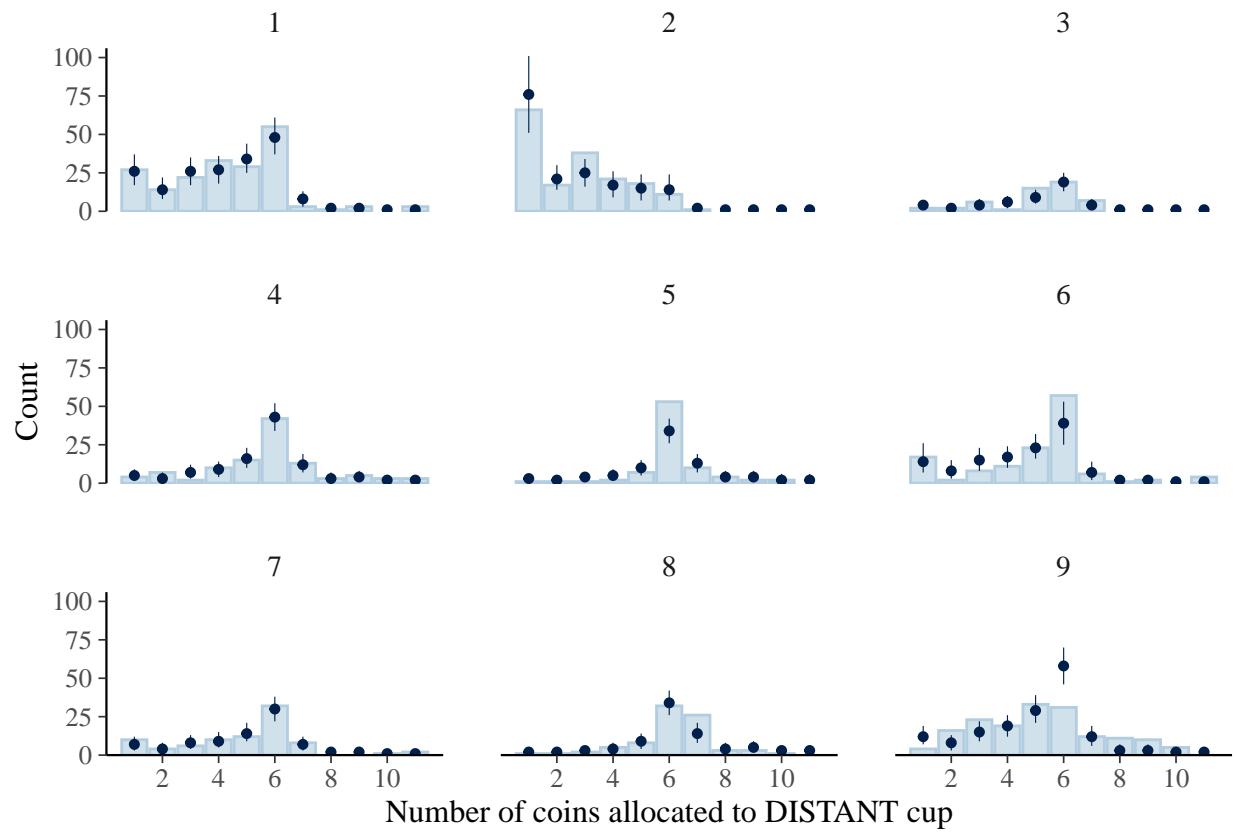


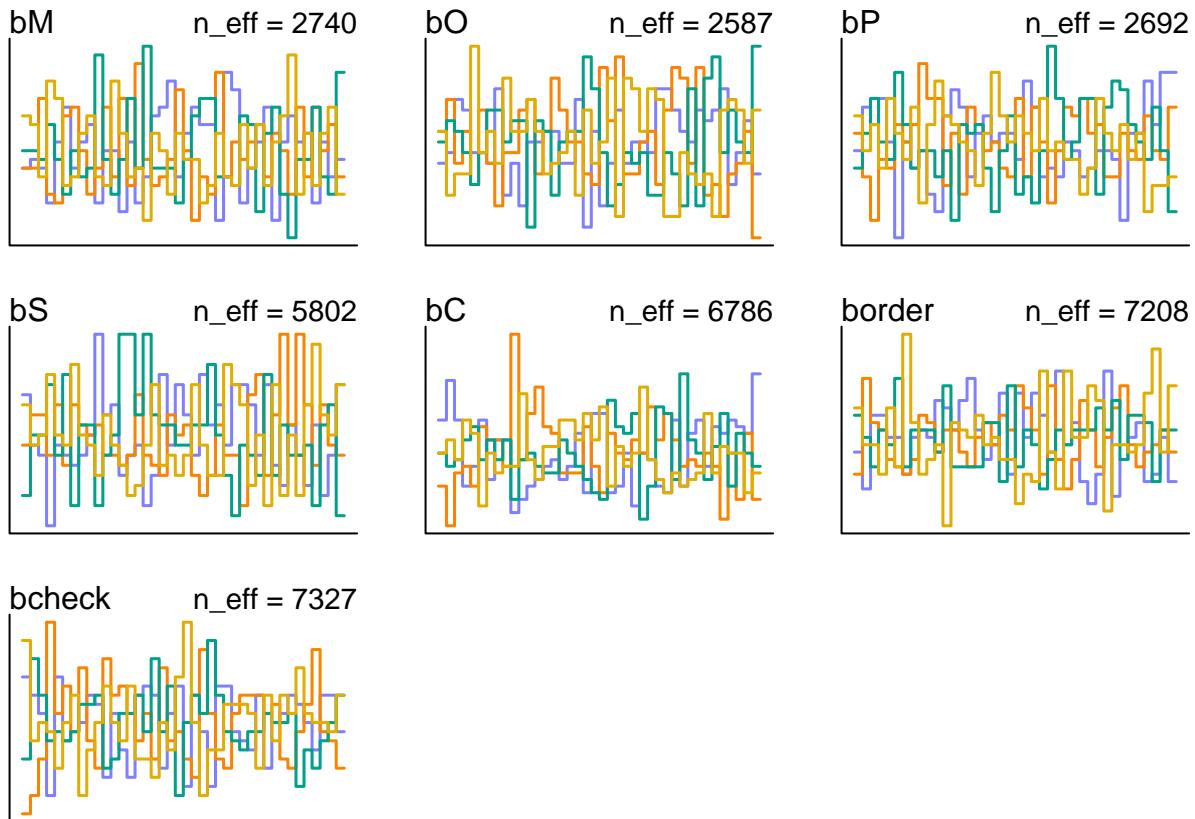




DG LOCAL ADD

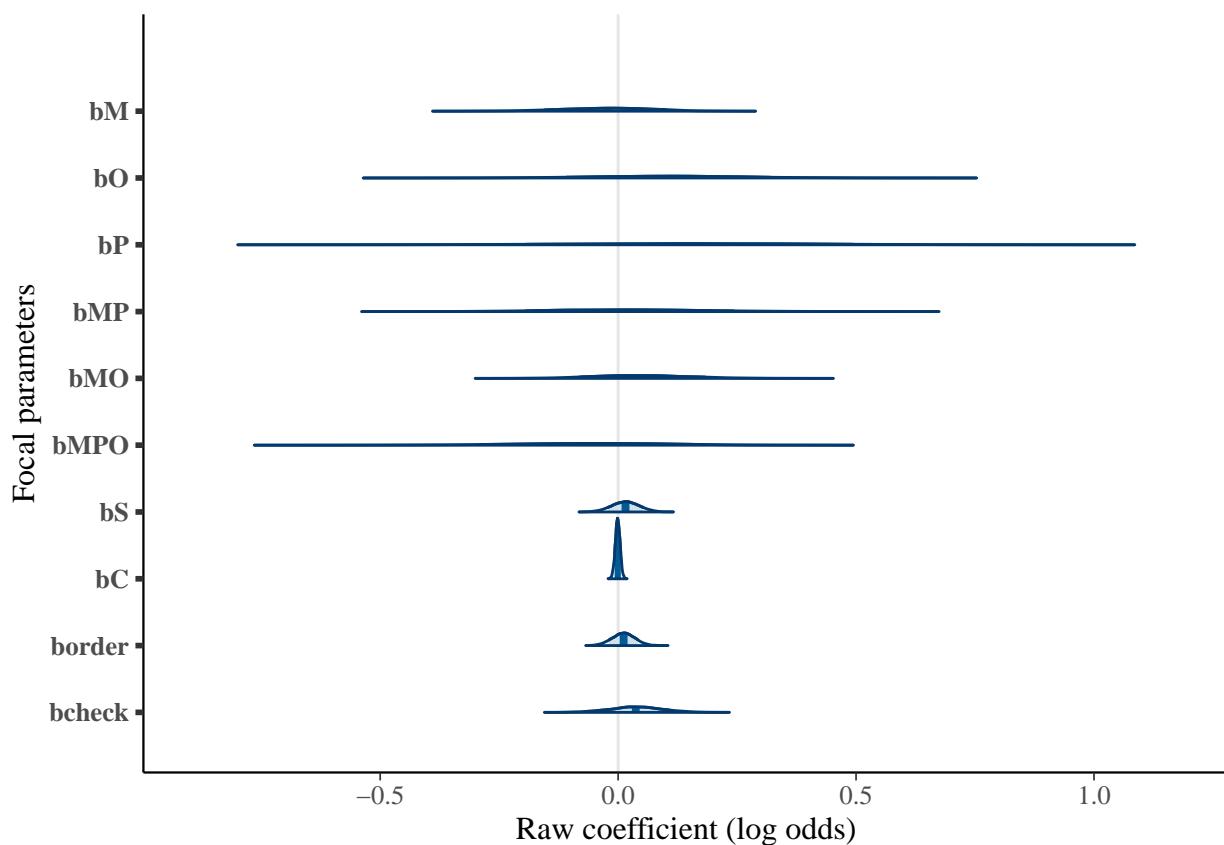


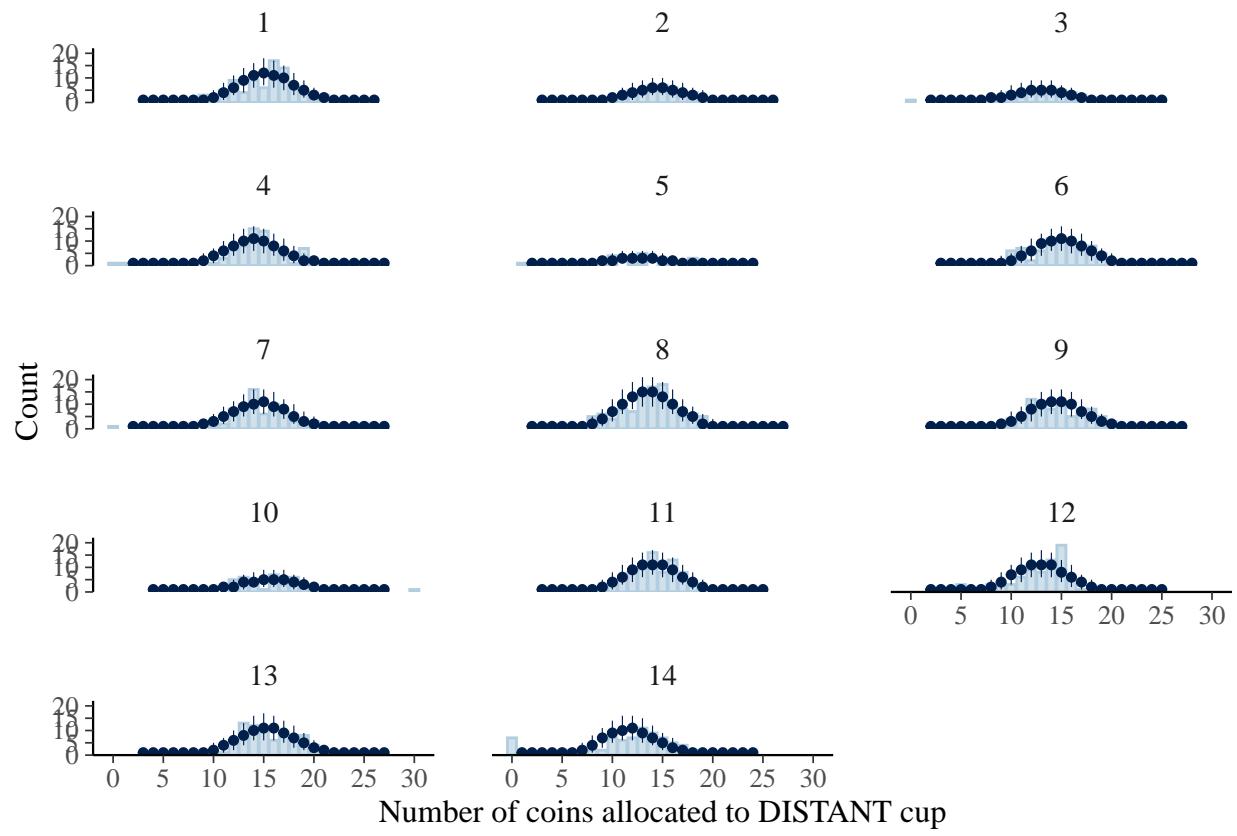


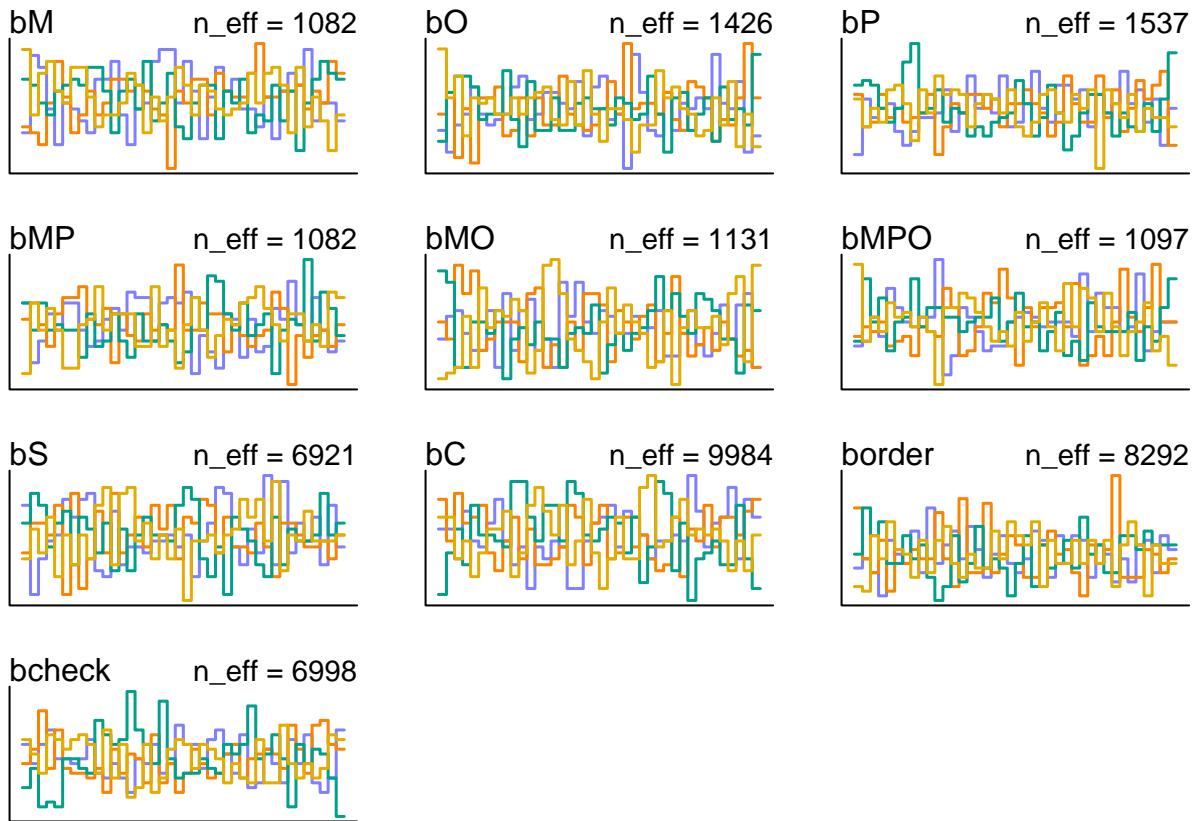


```
##           elpd_diff se_diff
## model2    0.0      0.0
## model1 -1.4     1.9
```

RAG INDEX SELF INT

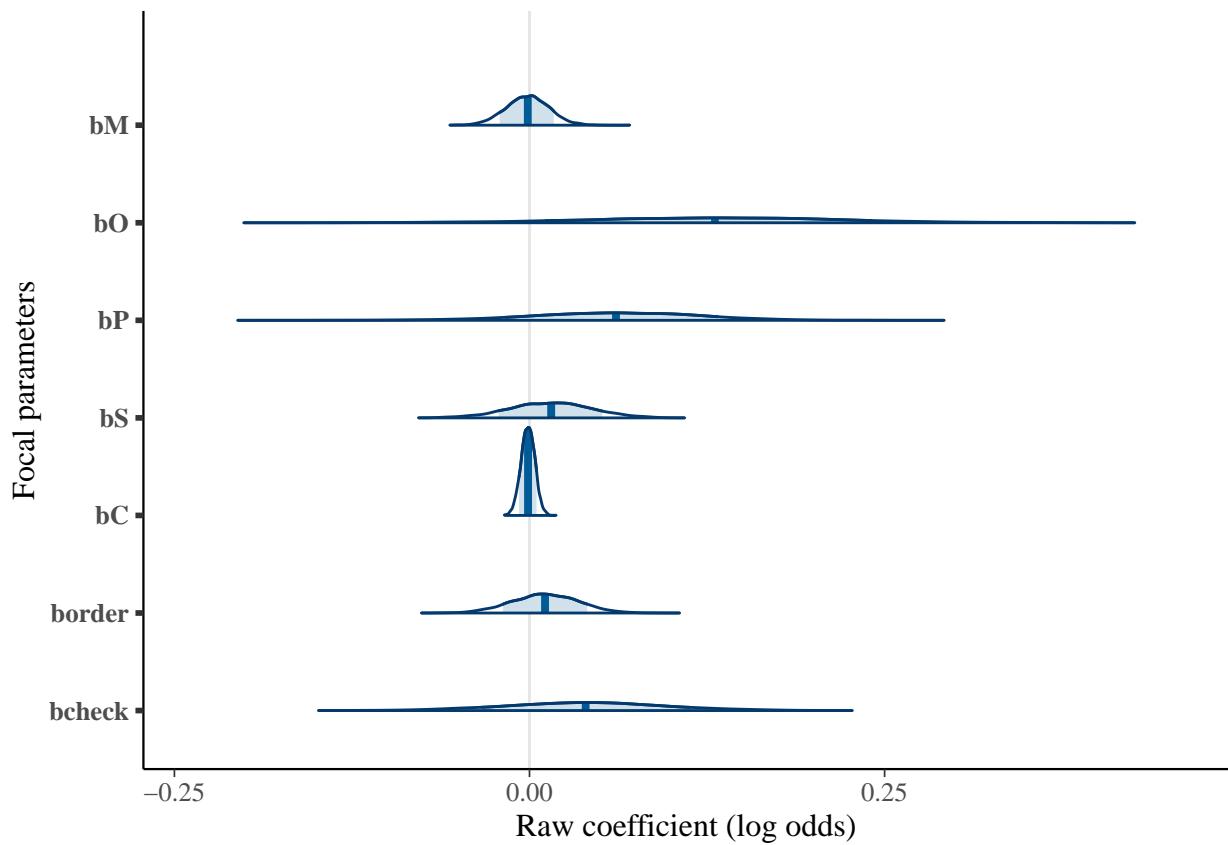


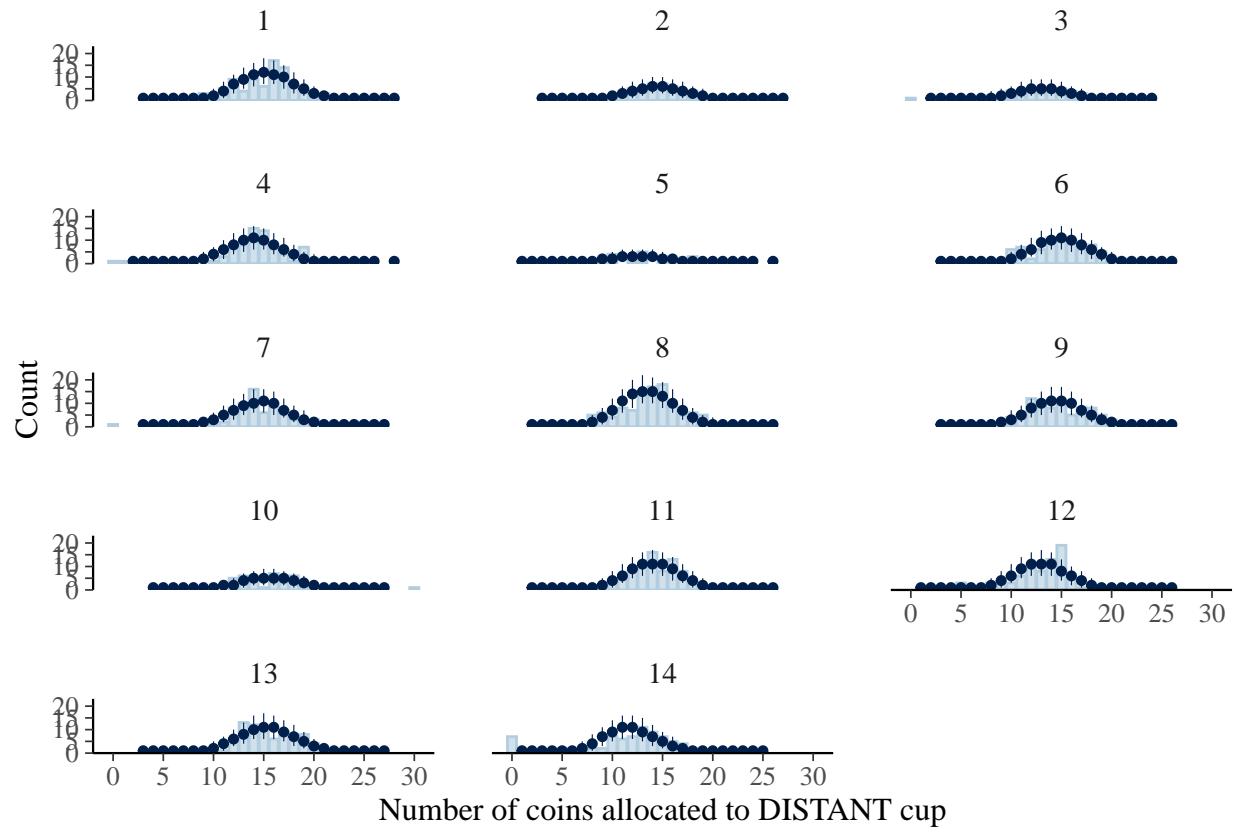


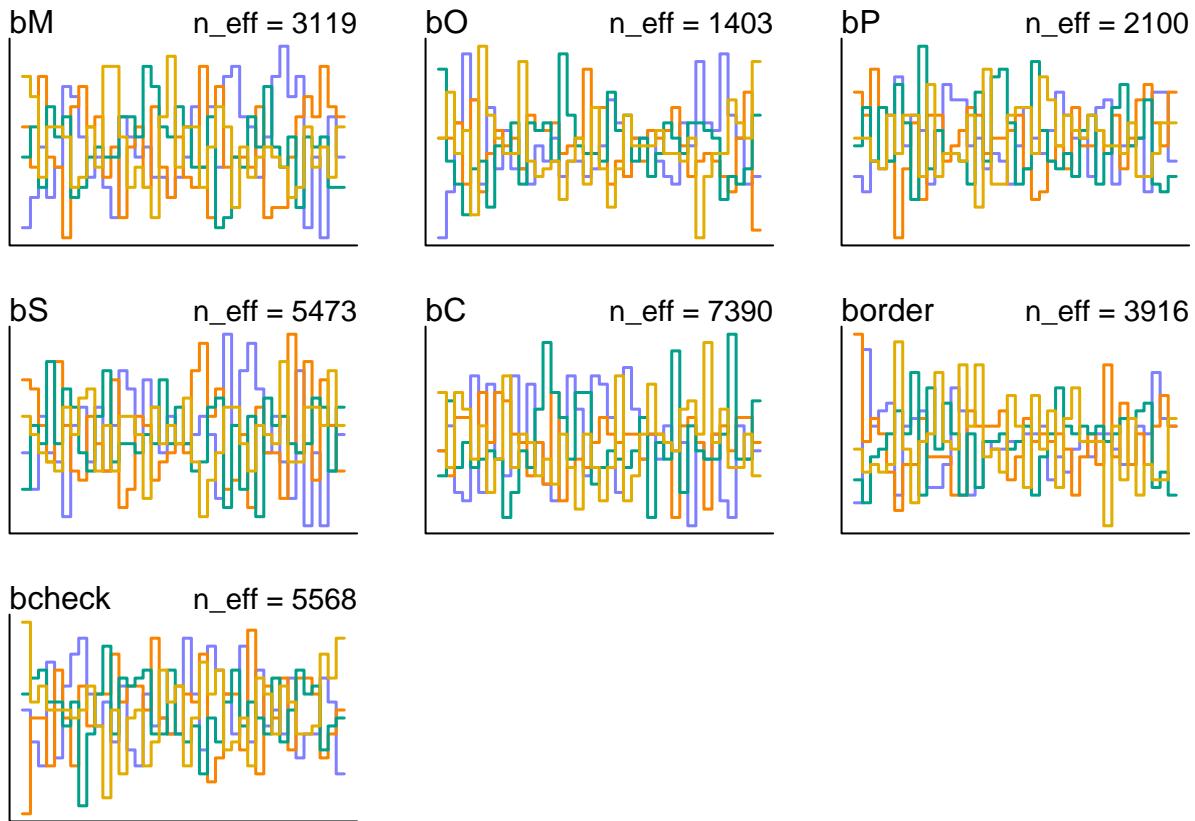


RAG INDEX SELF ADD

```
## Warning: 10 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```







```

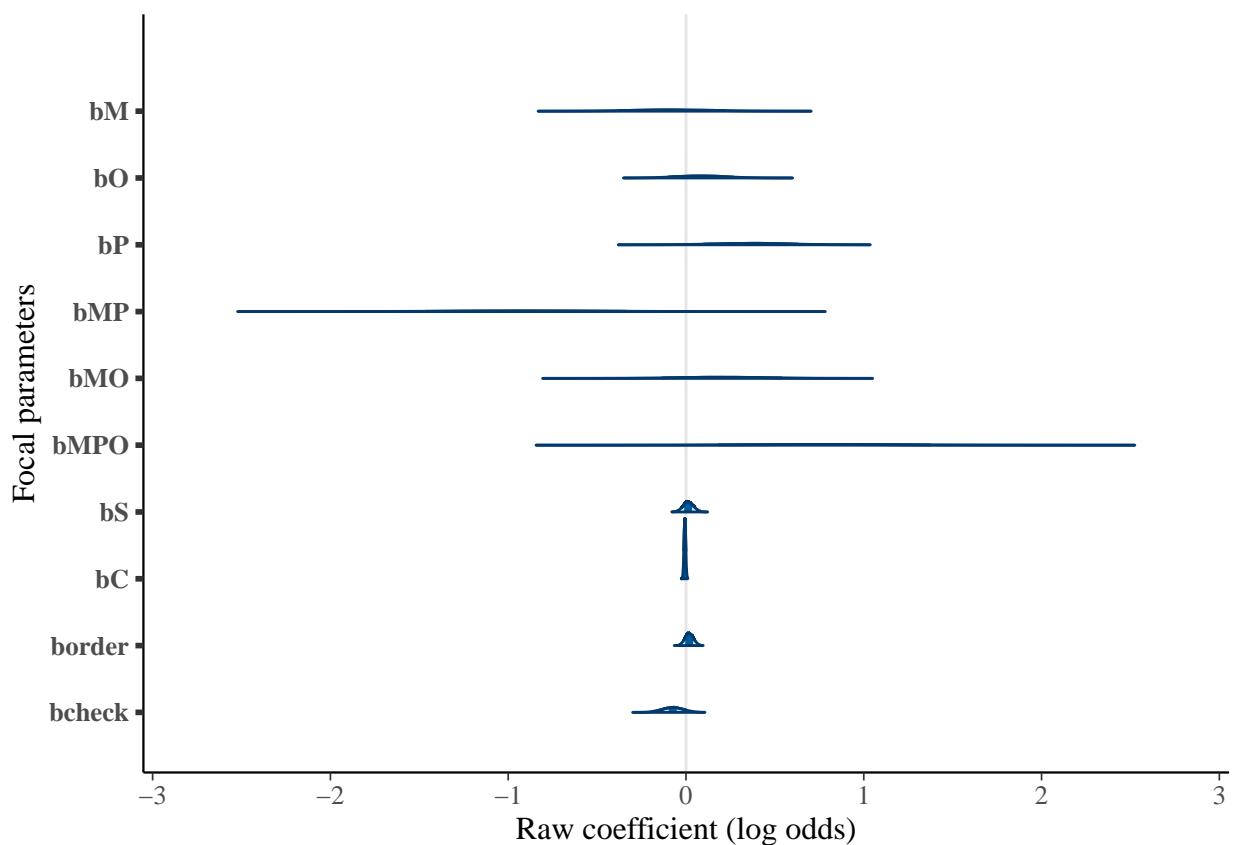
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

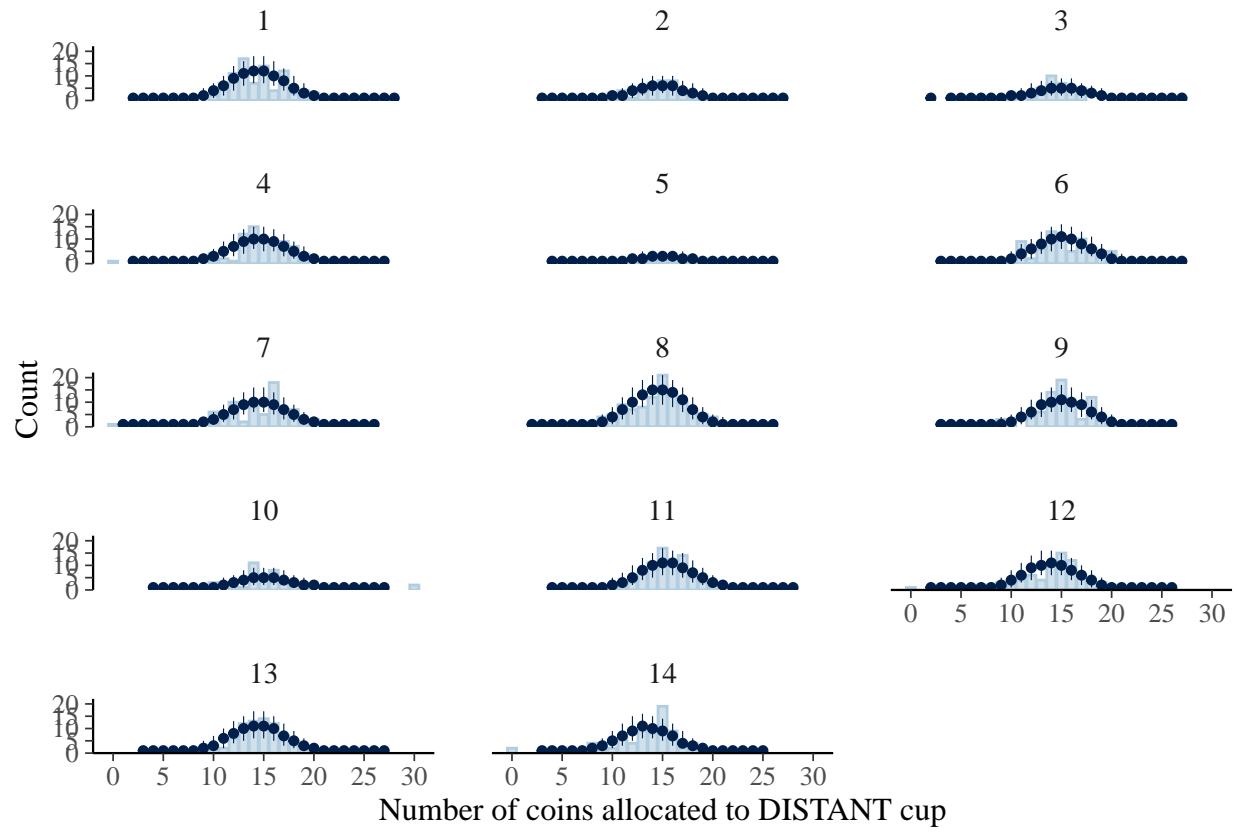
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

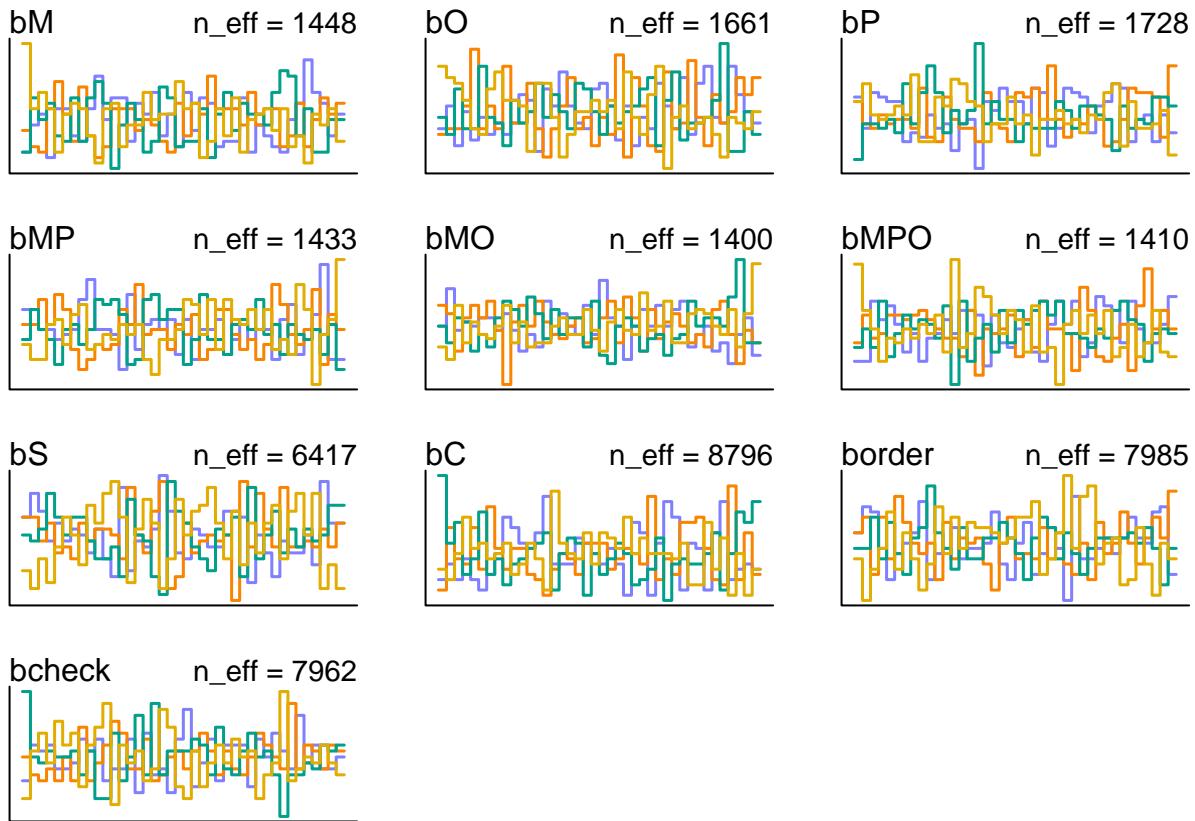
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -8.3     2.6

```

RAG INDEX LOCAL INT

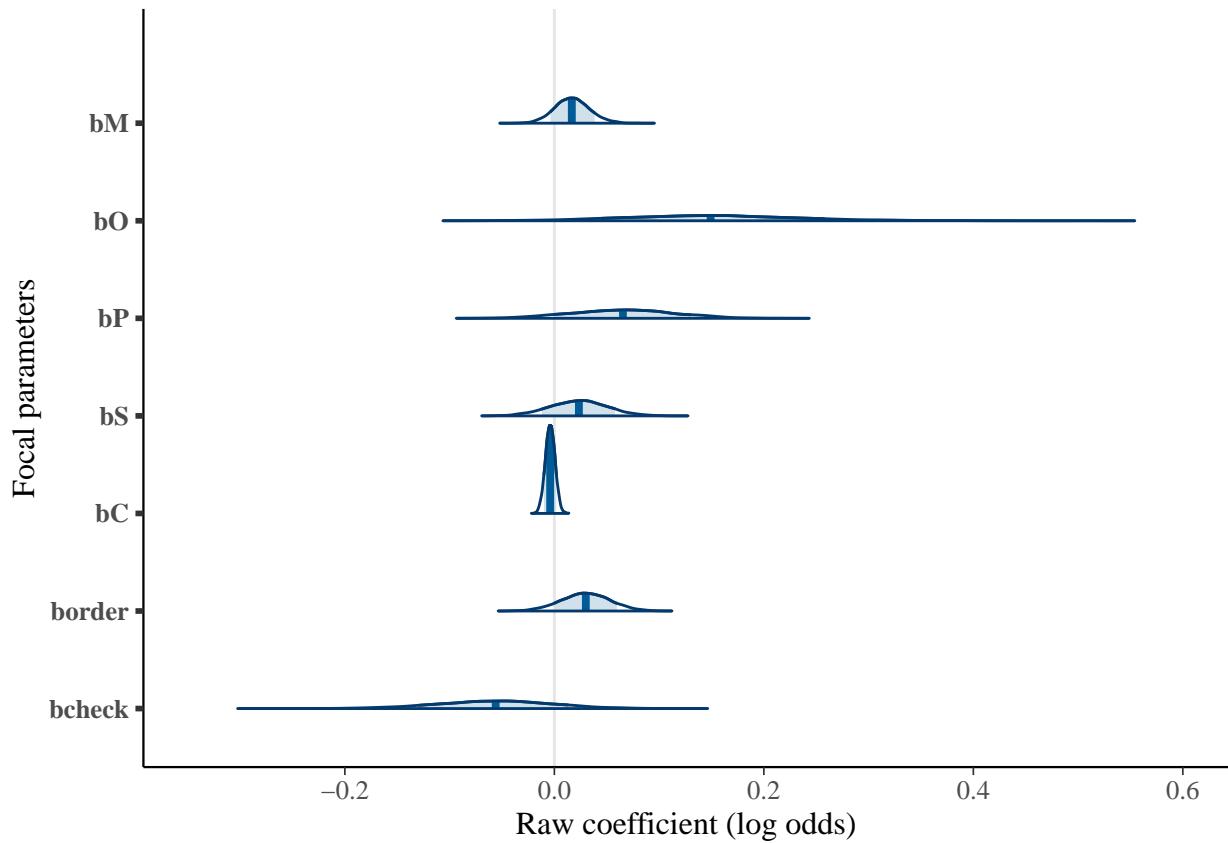


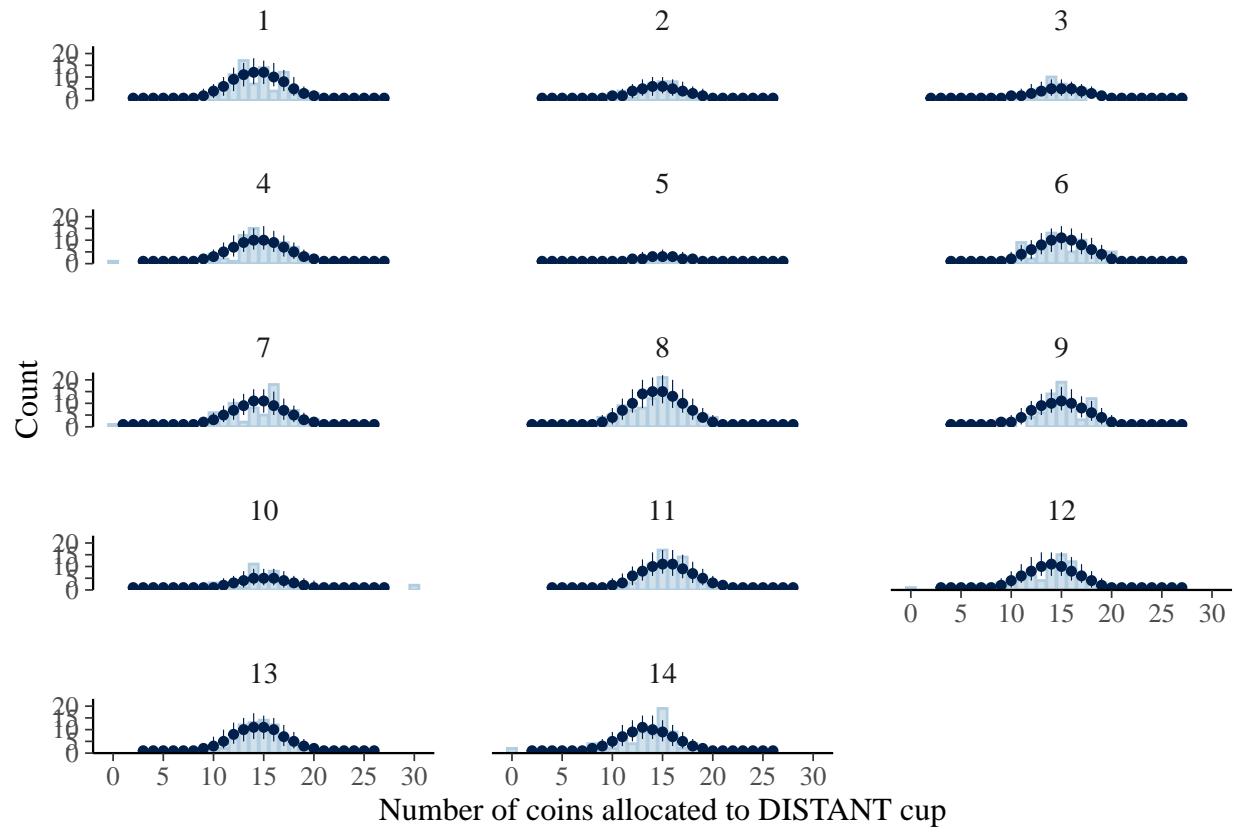


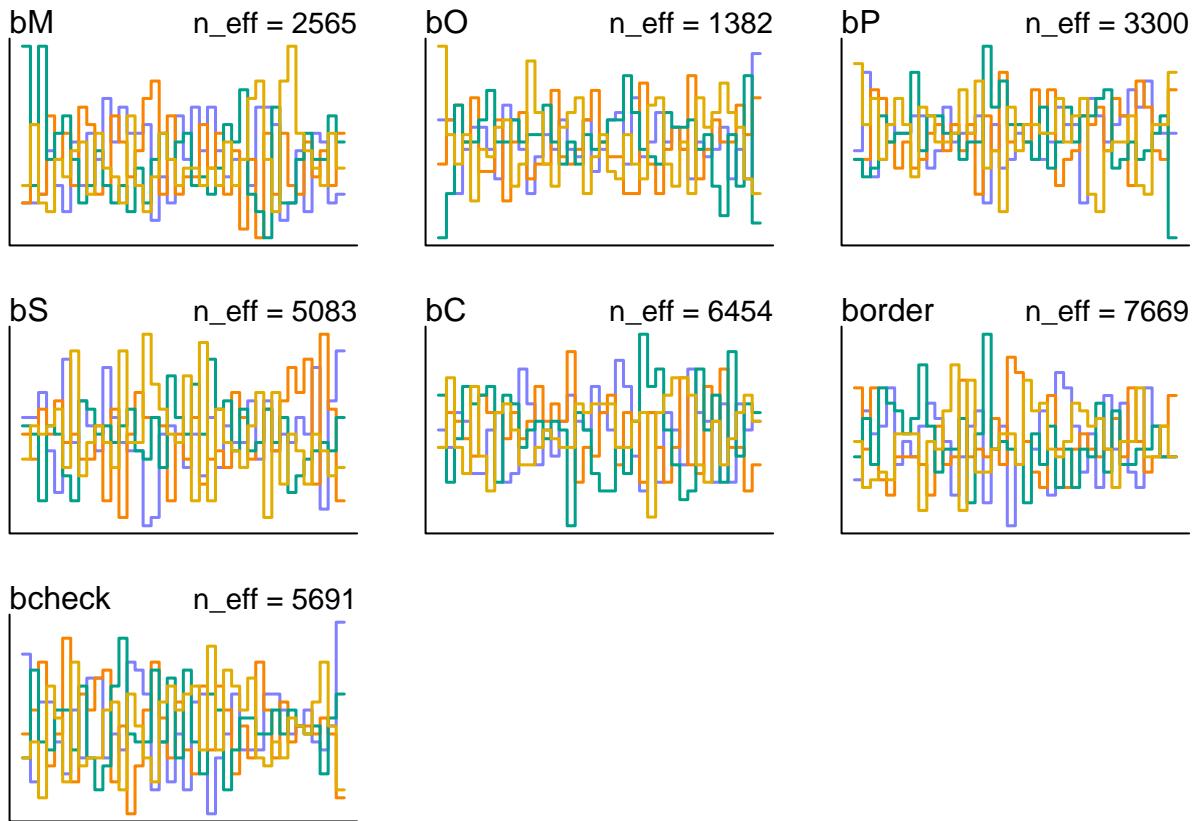


RAG INDEX LOCAL ADD

```
## Warning: 50 of 4000 (1.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```





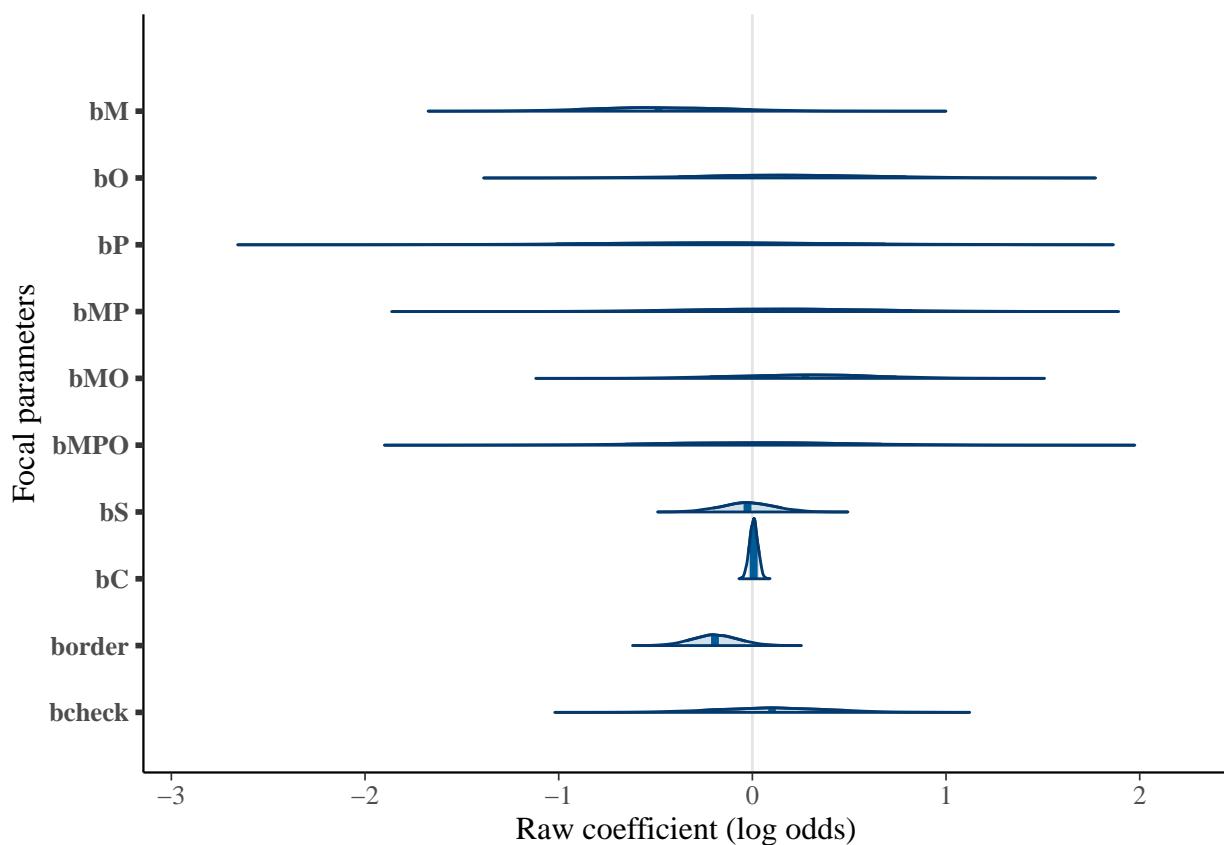


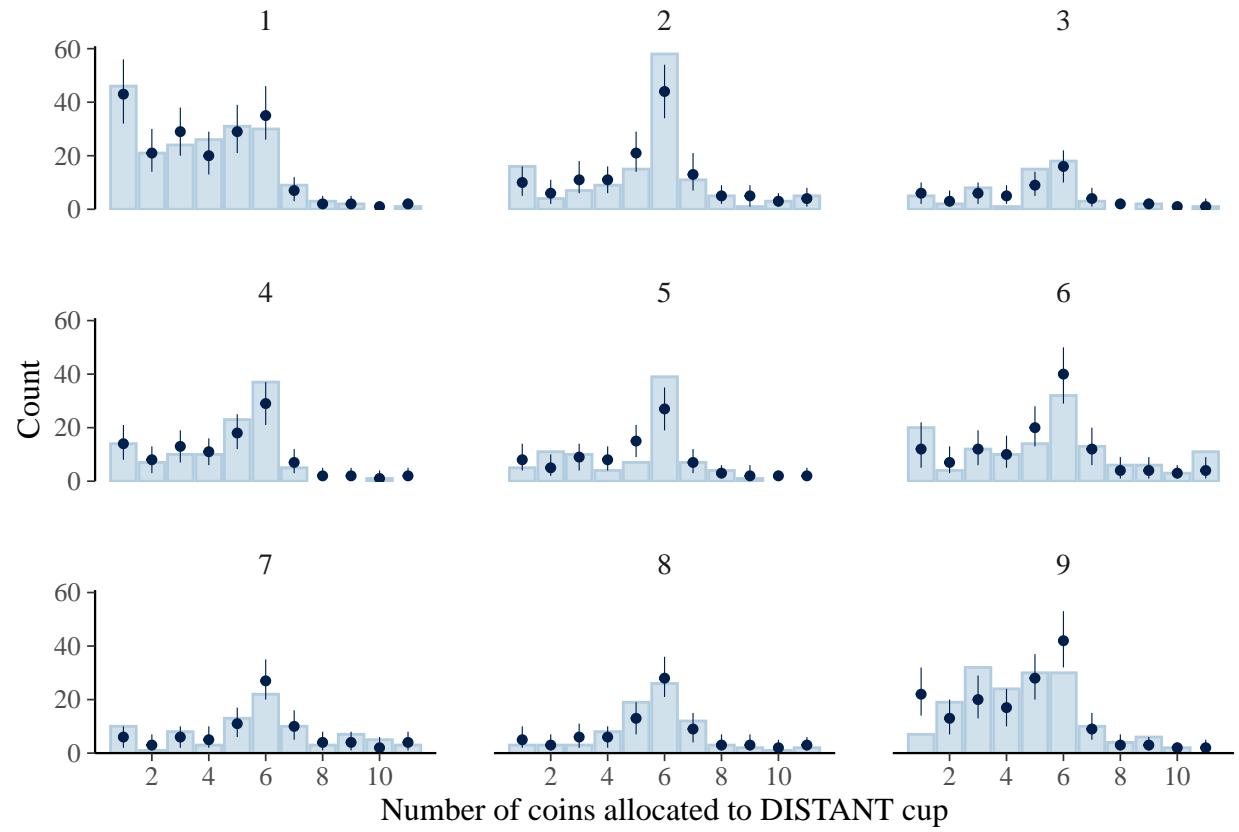
```

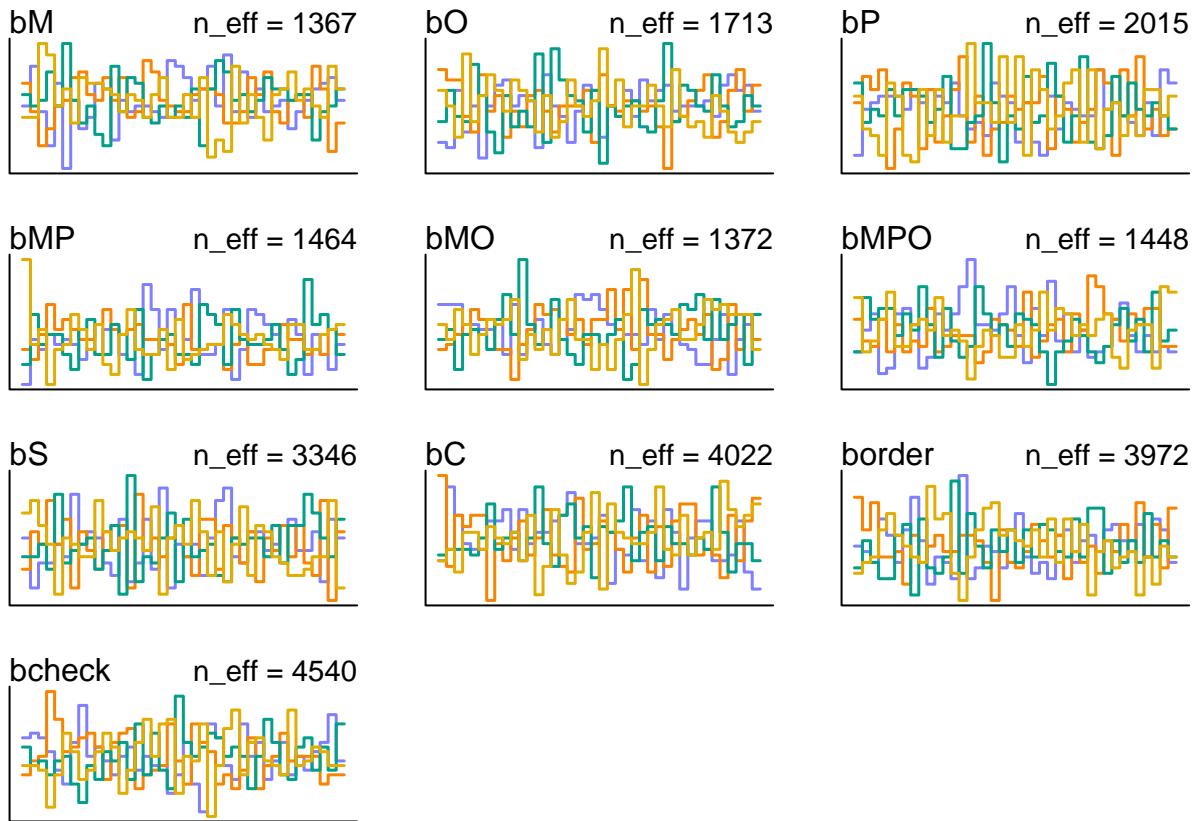
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -8.3     2.6

```

DG INDEX SELF INT

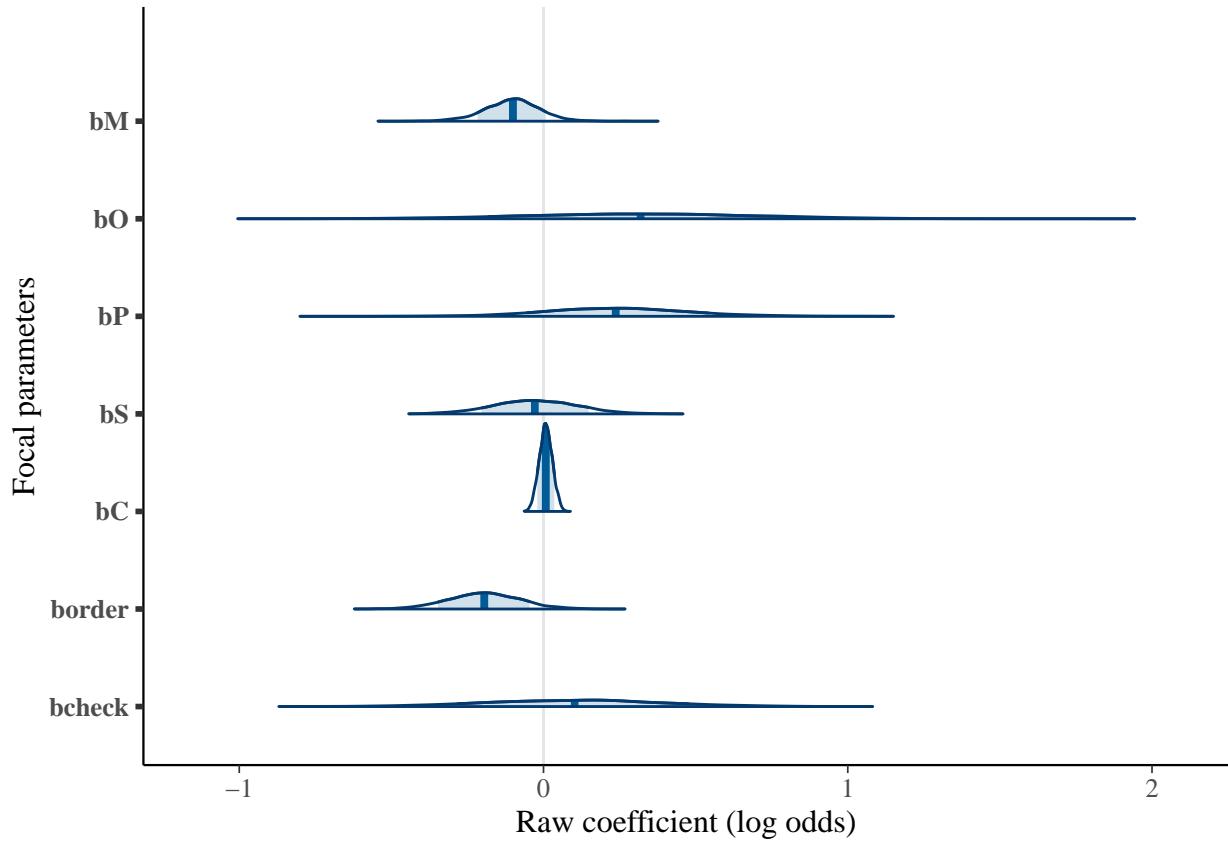


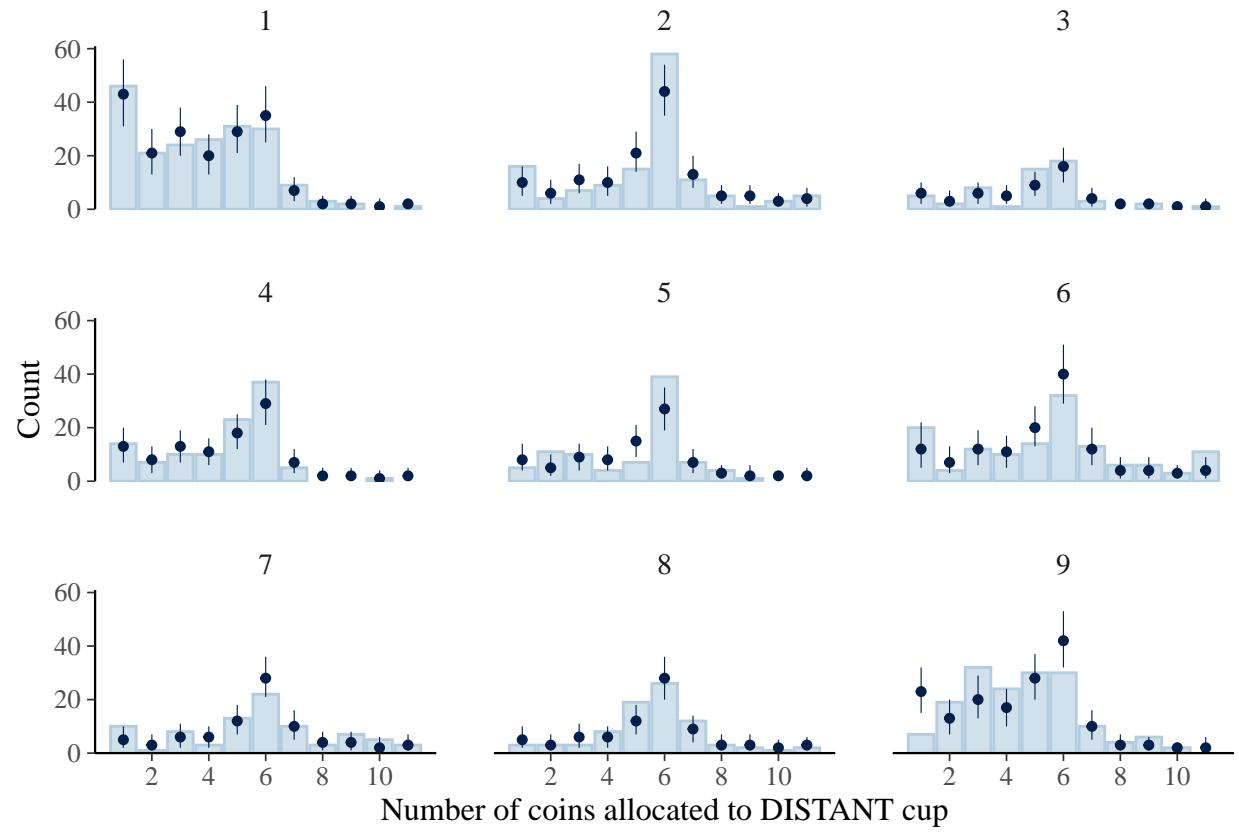


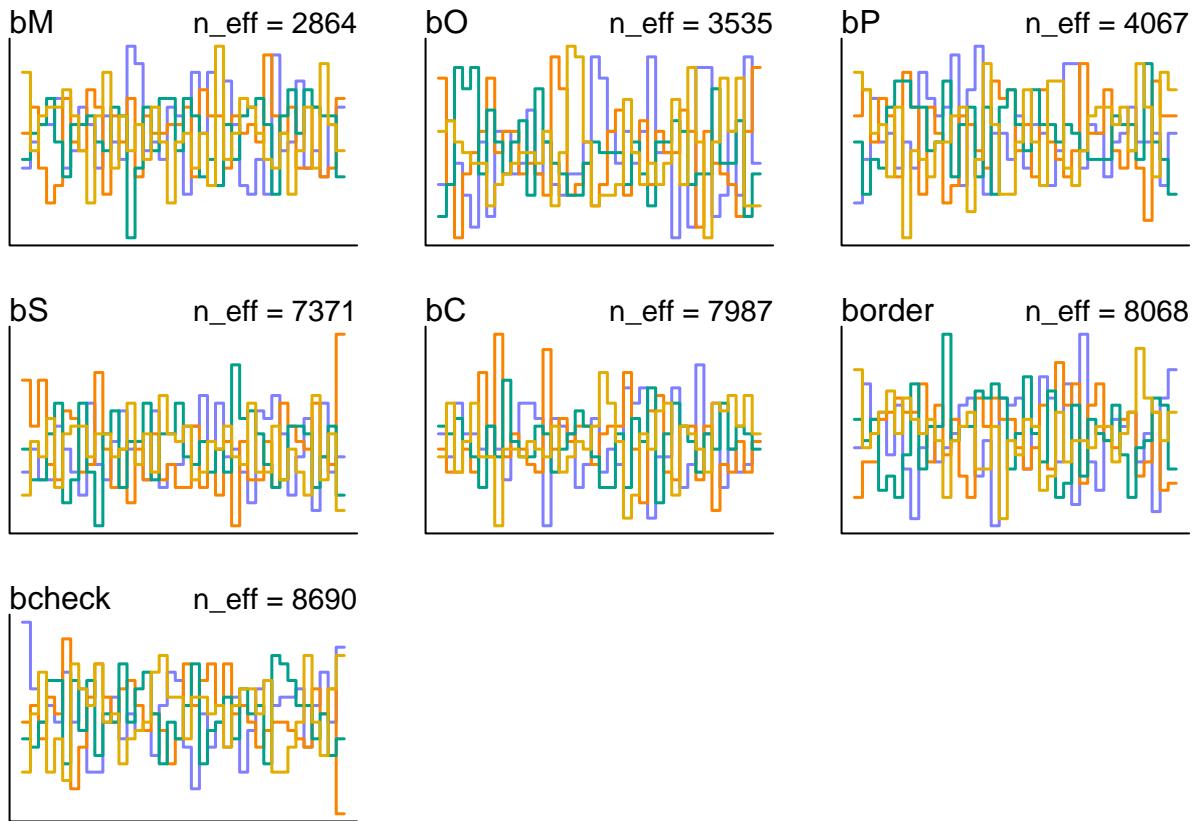


DG INDEX SELF ADD

```
## Warning: 1 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```

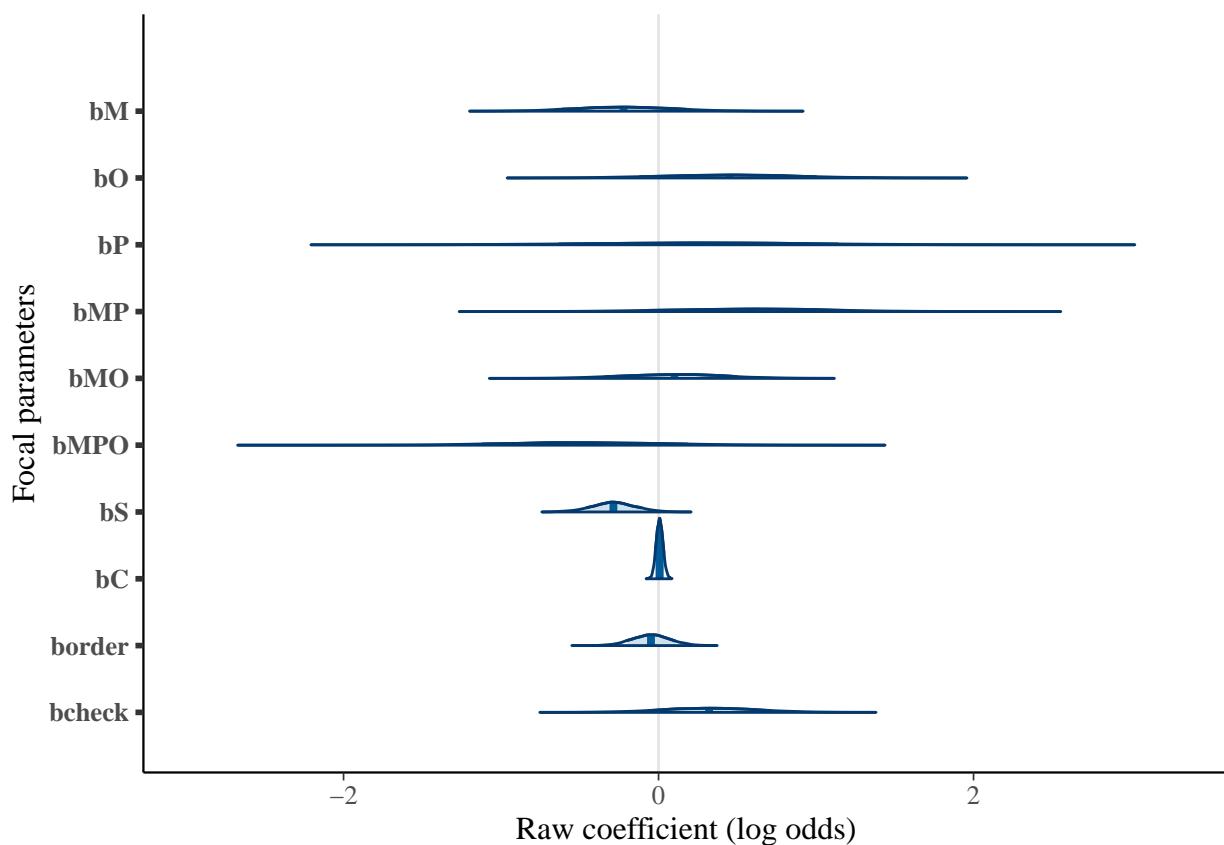


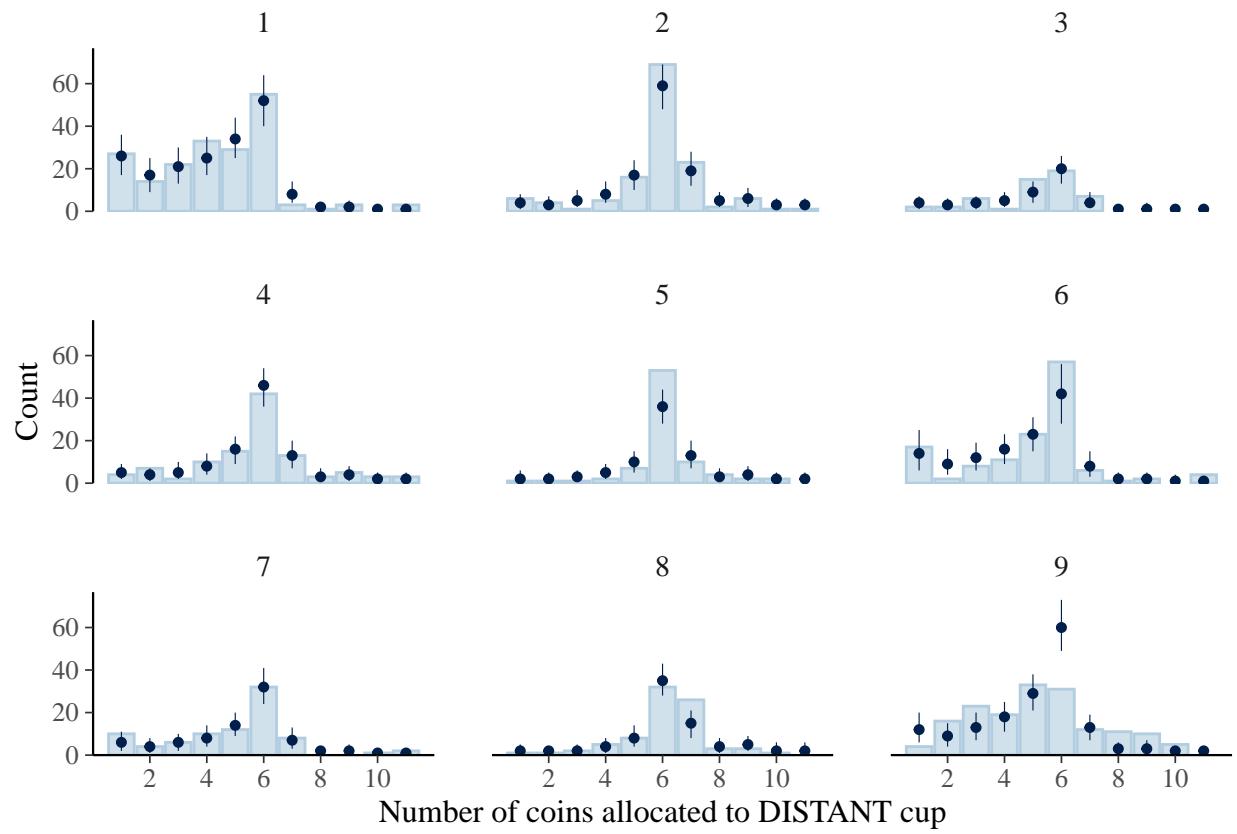


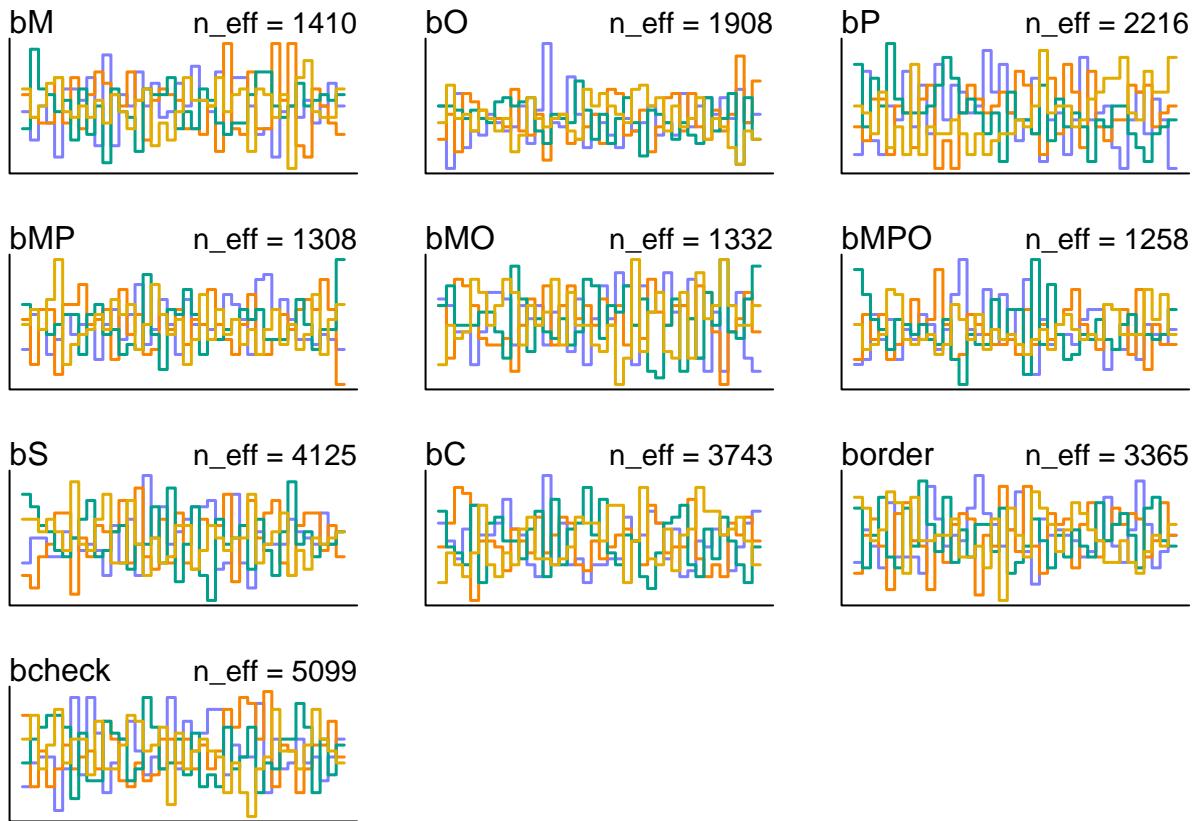


```
##          elpd_diff se_diff
## model2    0.0      0.0
## model1 -1.3     2.7
```

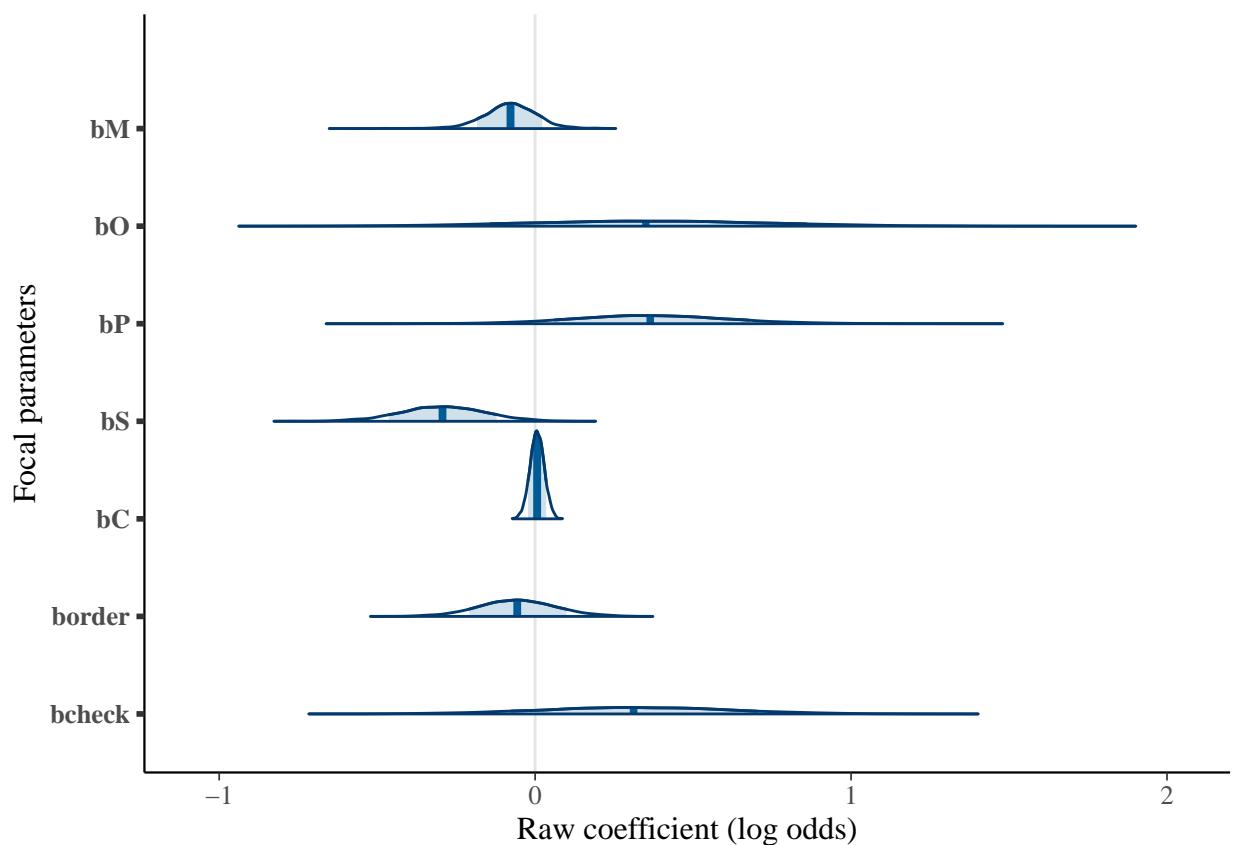
DG INDEX LOCAL INT

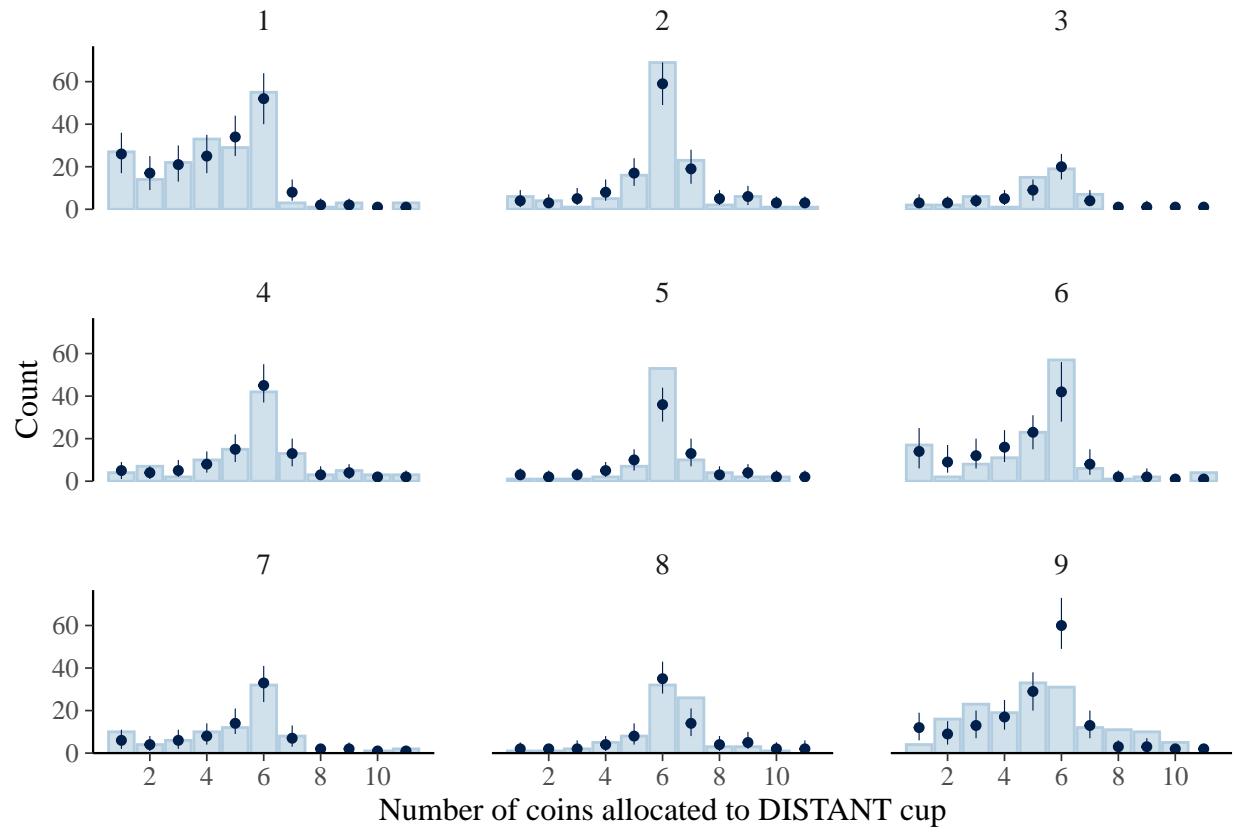


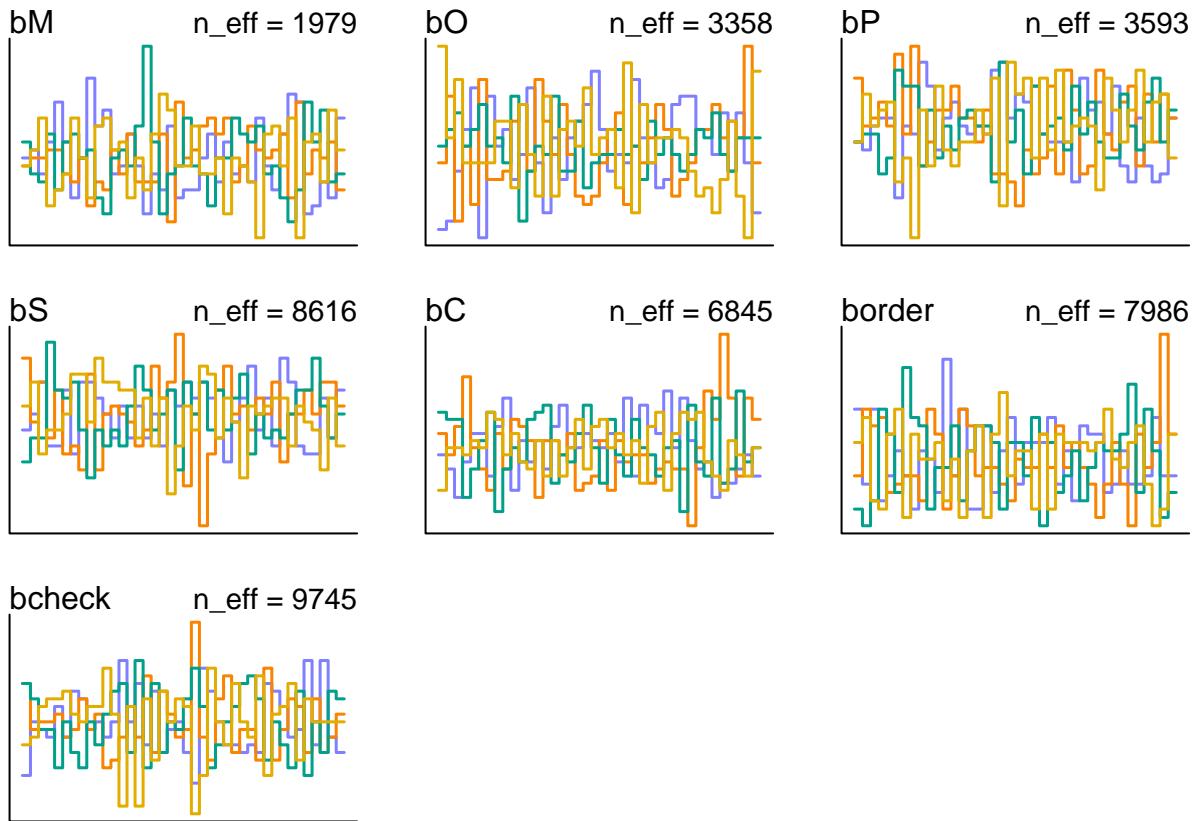




DG INDEX LOCAL ADD

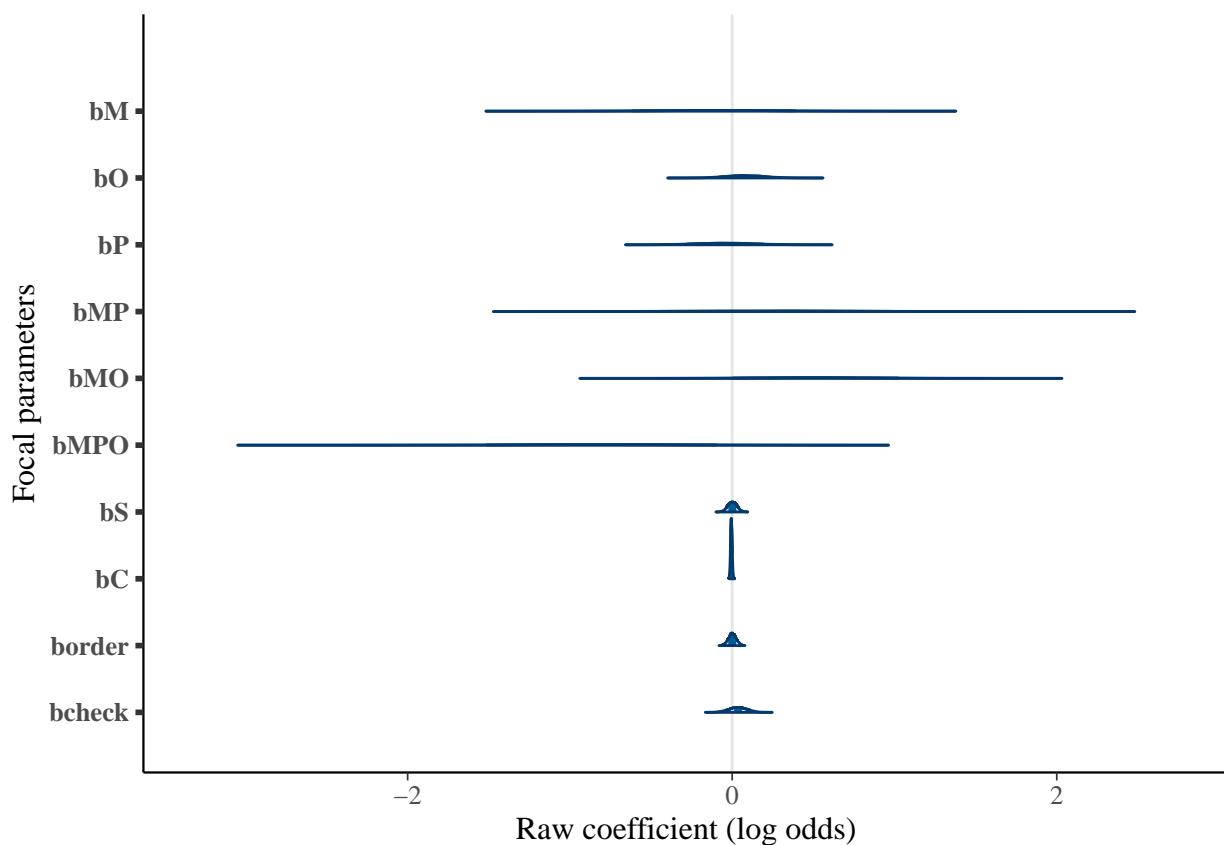


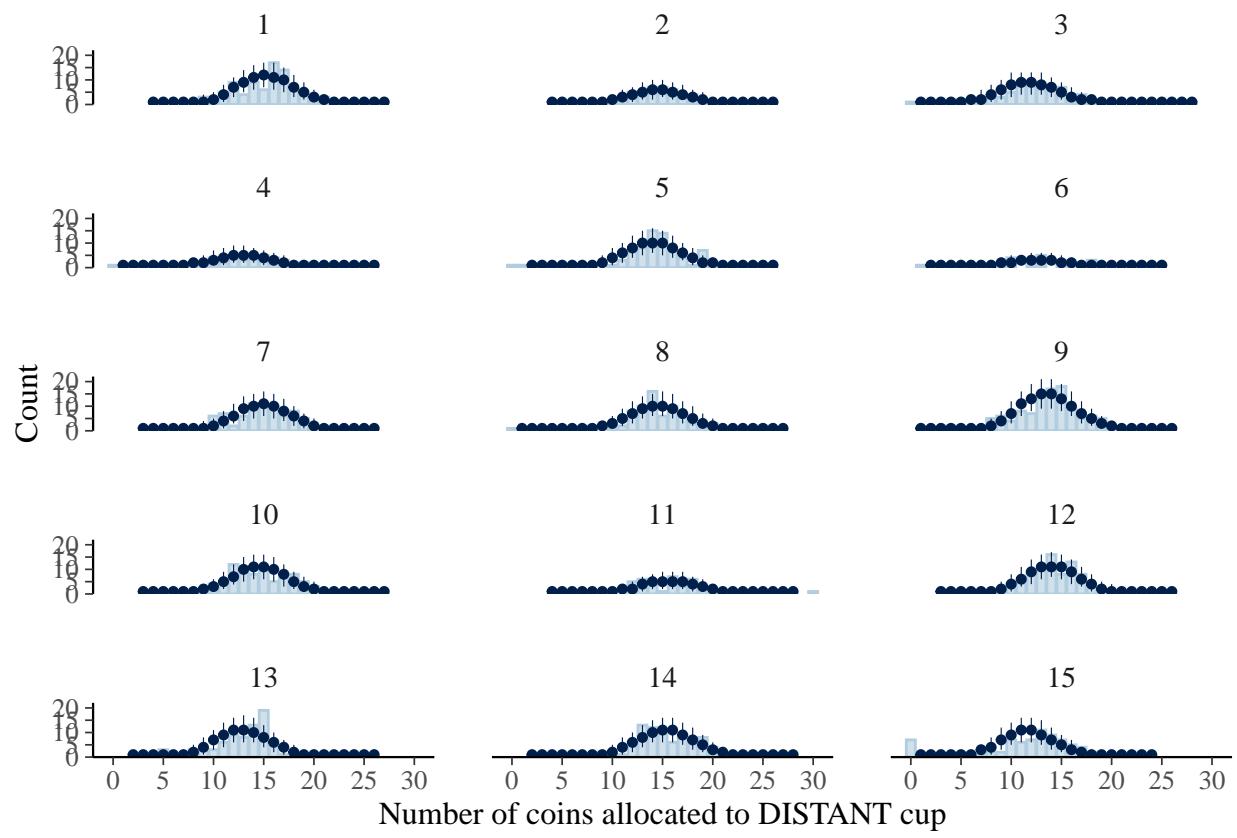


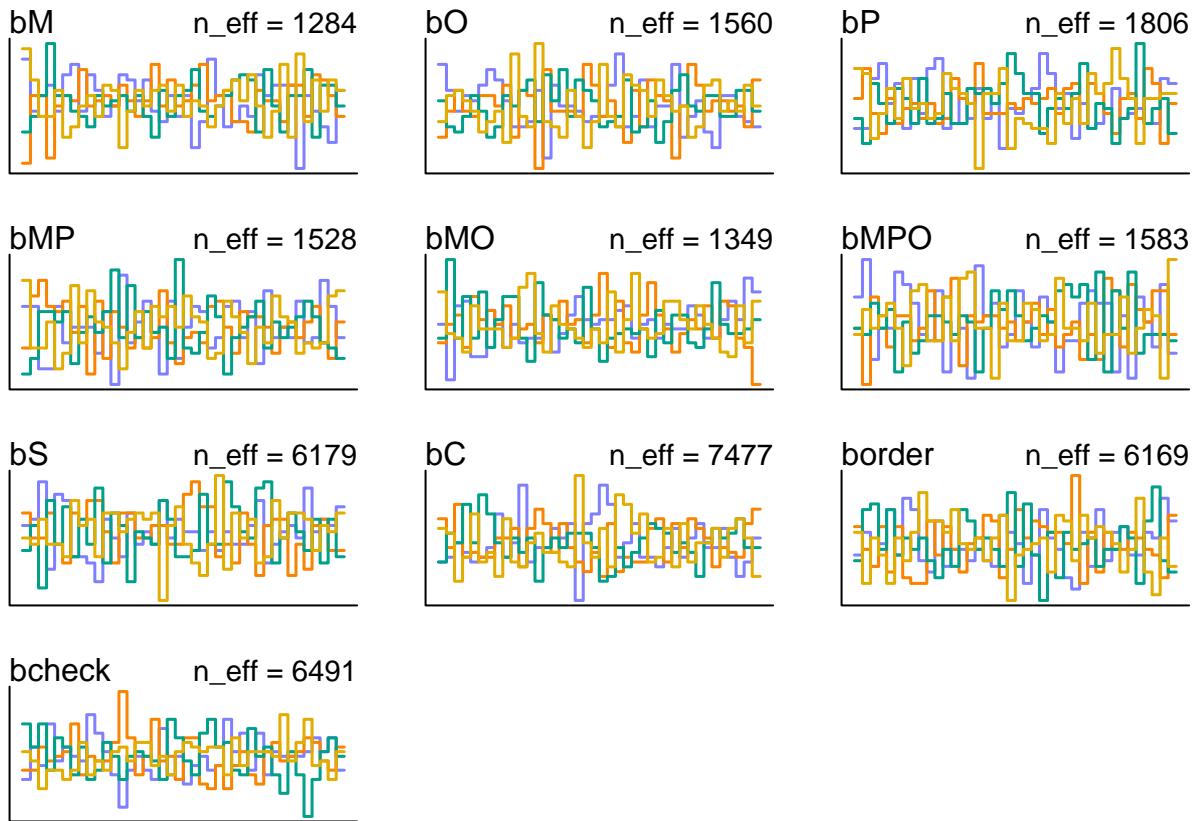


```
##           elpd_diff se_diff
## model2    0.0      0.0
## model1   -2.2     1.6
```

RAG SPEC SELF INT

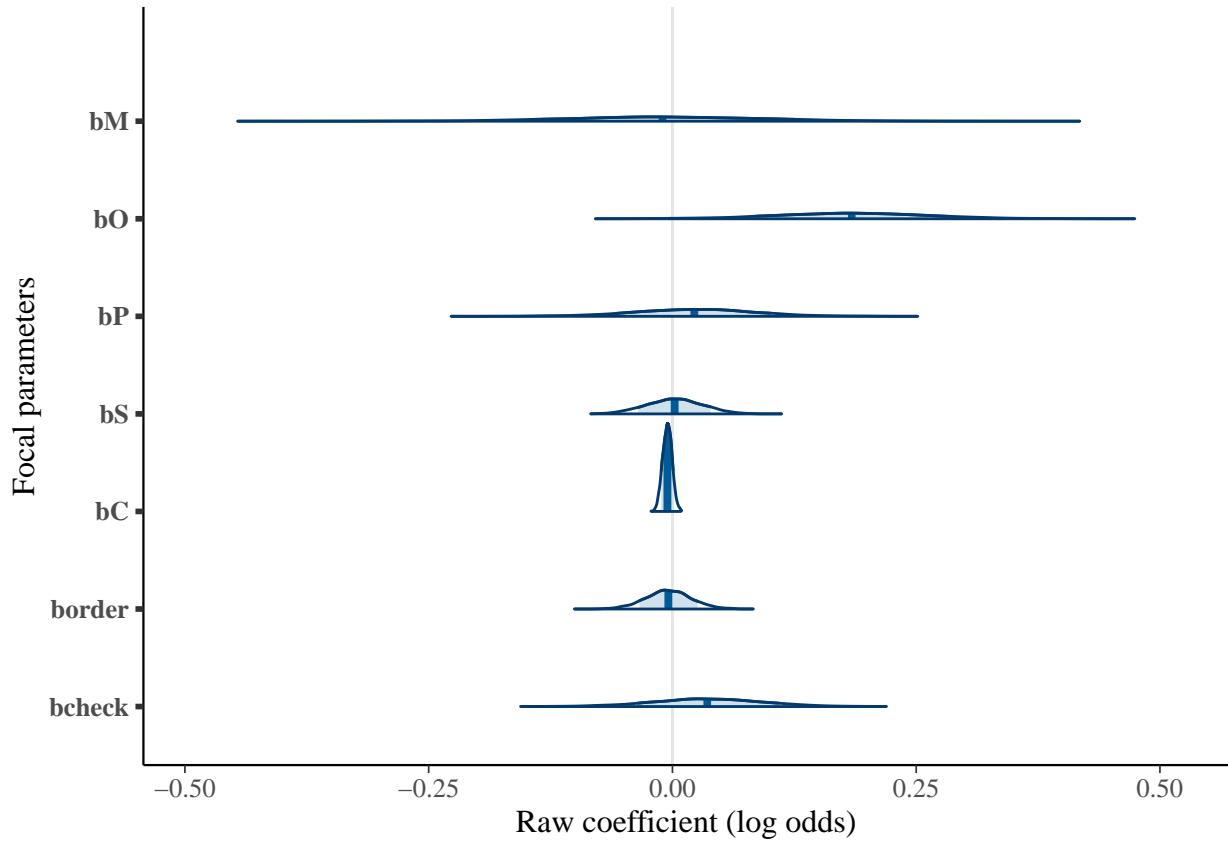


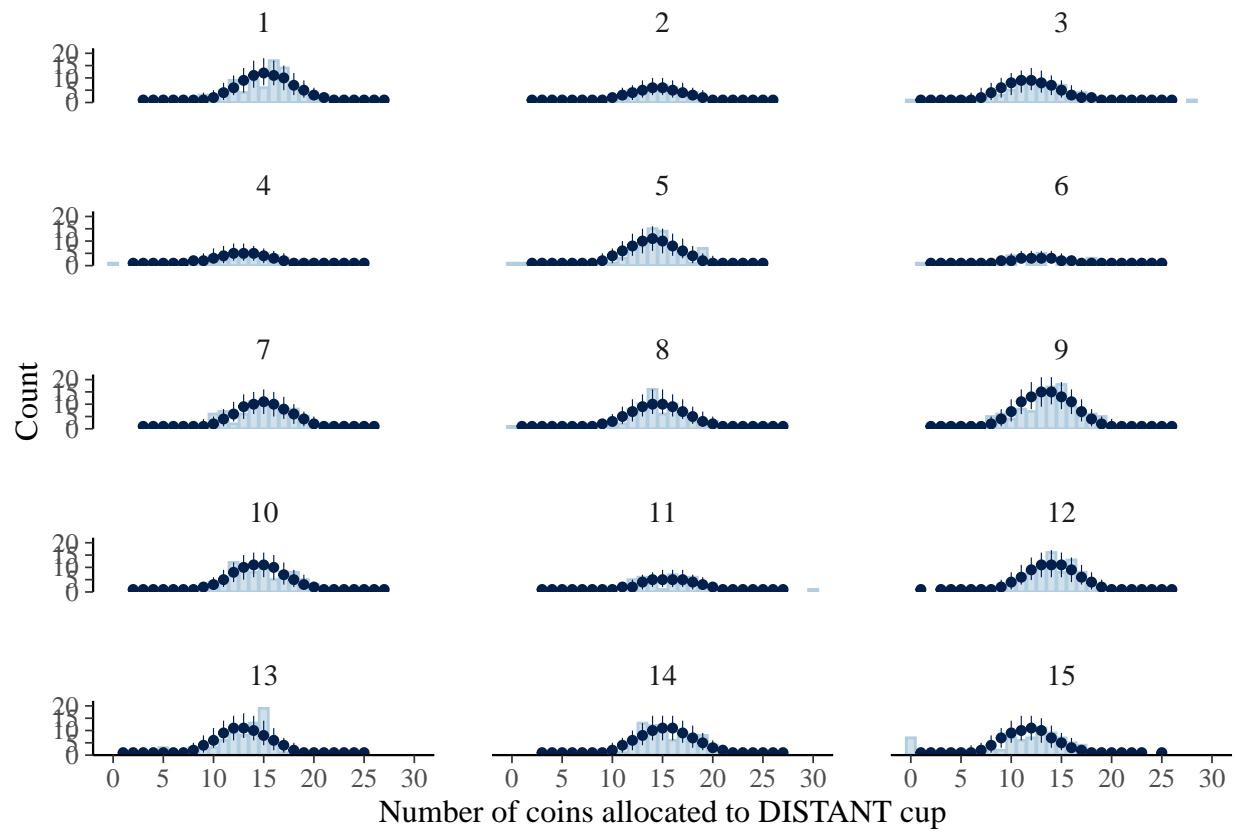


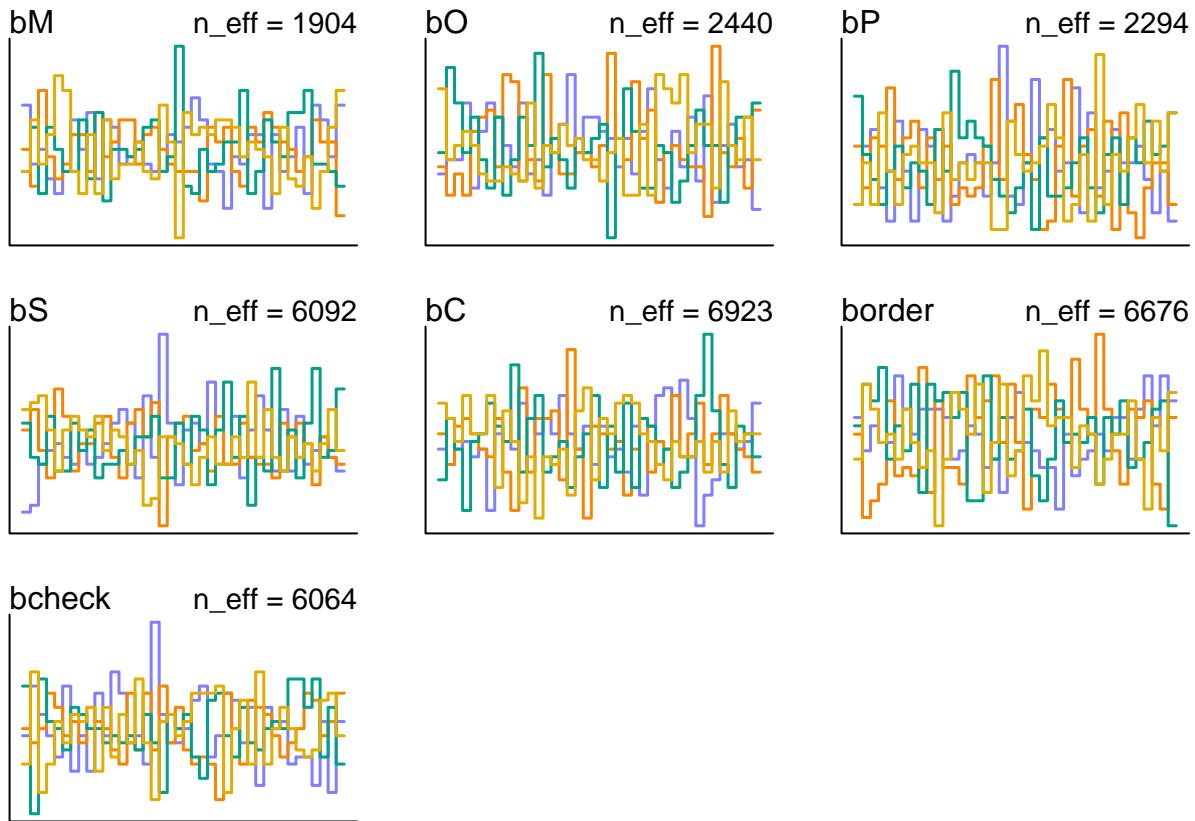


RAG SPEC SELF ADD

```
## Warning: 10 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```





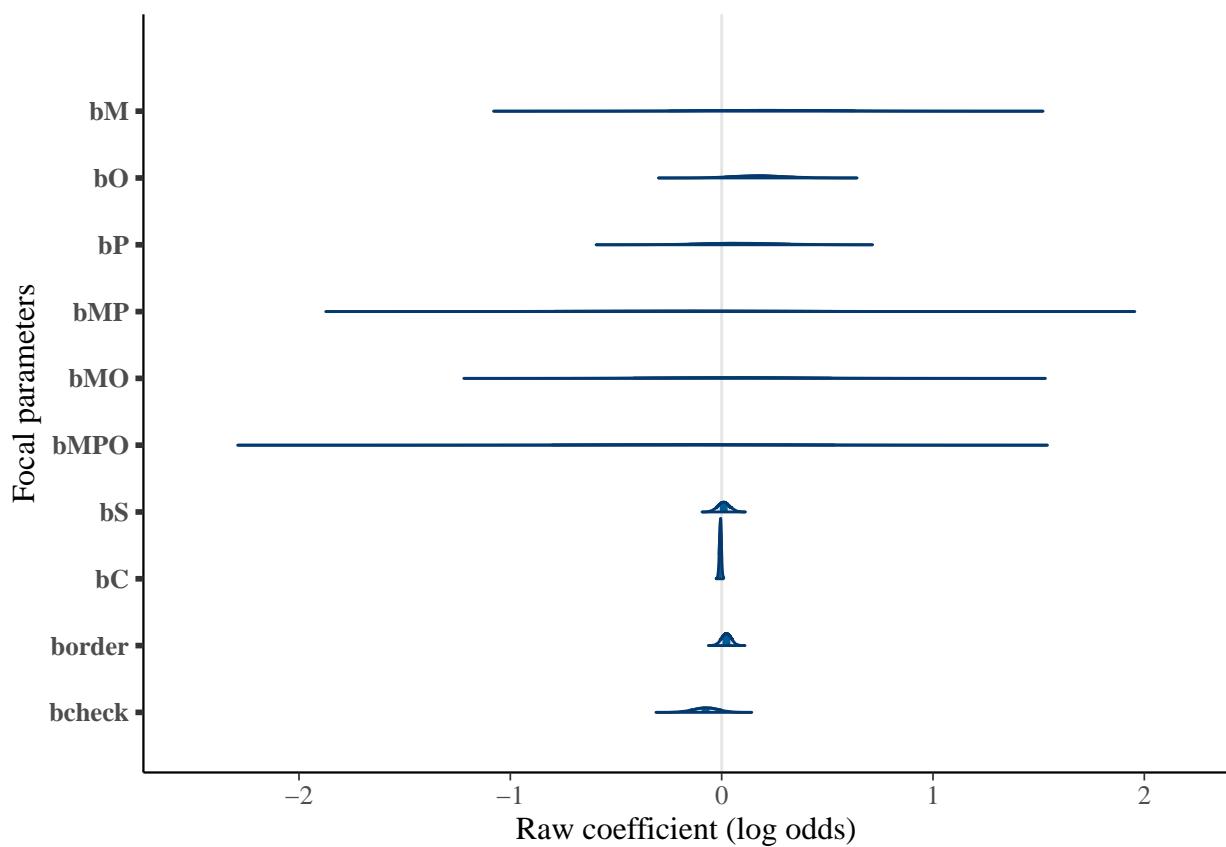


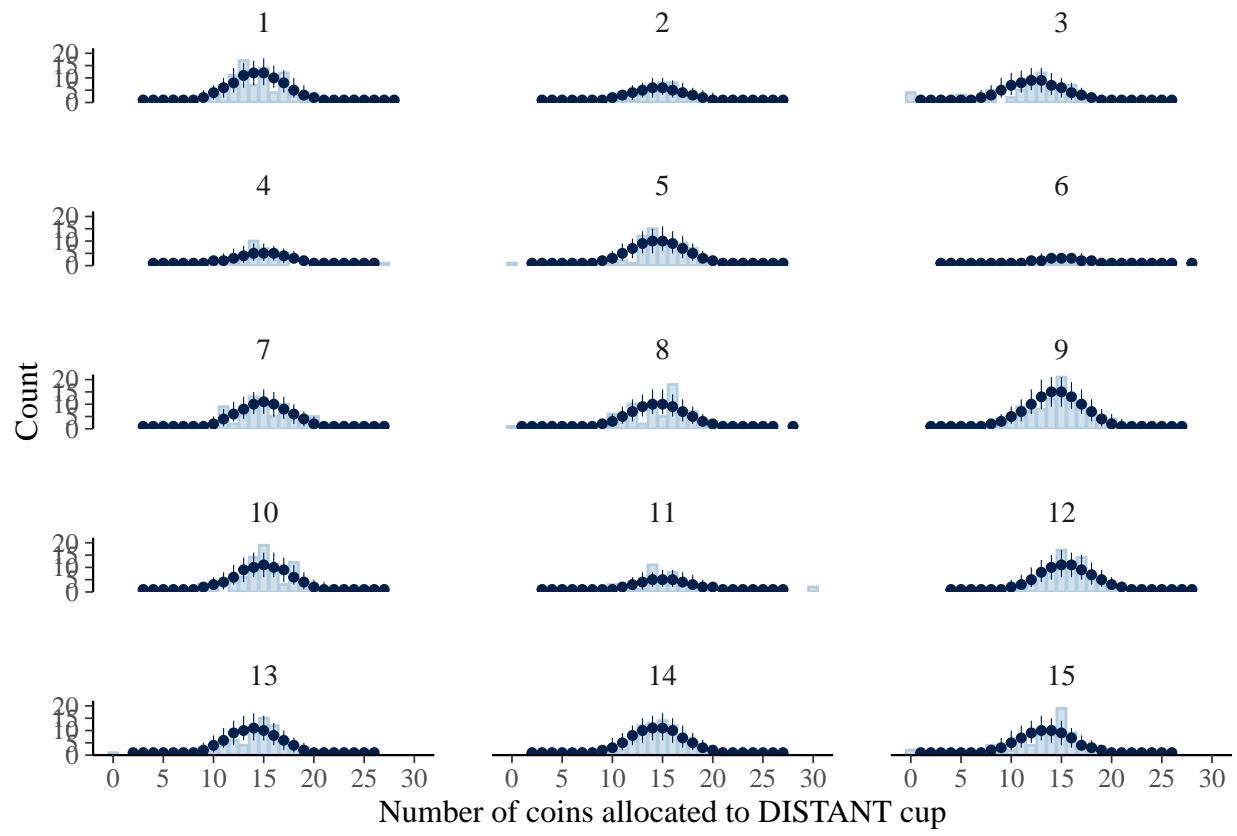
```
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

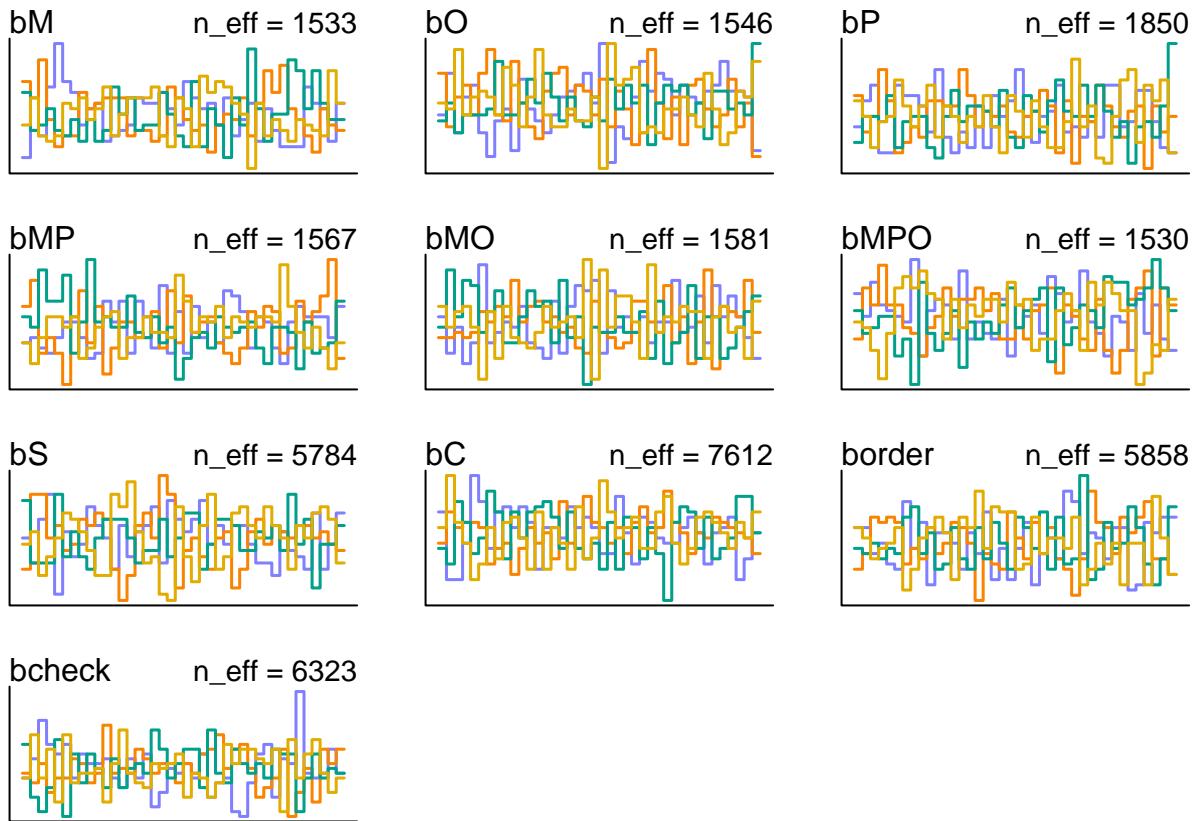
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

##           elpd_diff se_diff
## model2    0.0      0.0
## model1   -3.2     3.8
```

RAG SPEC LOCAL INT

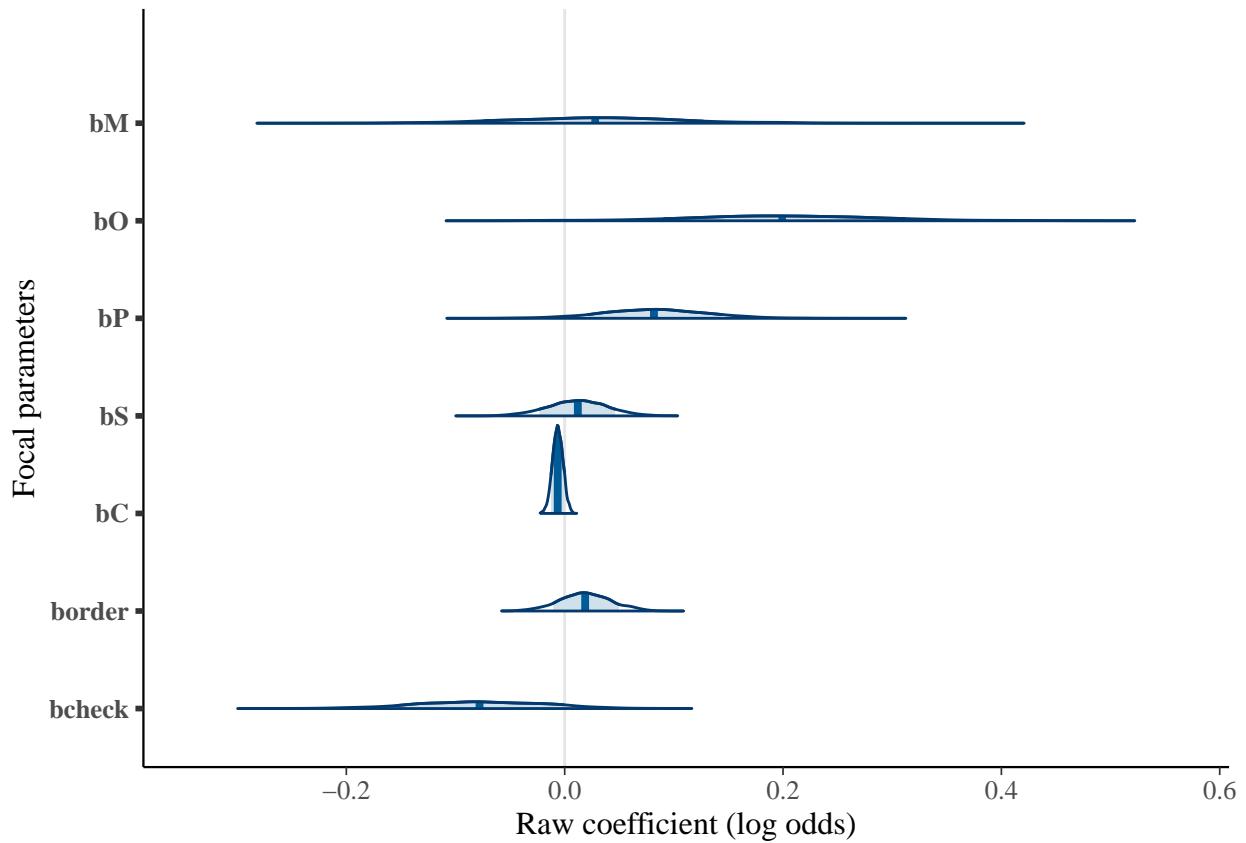


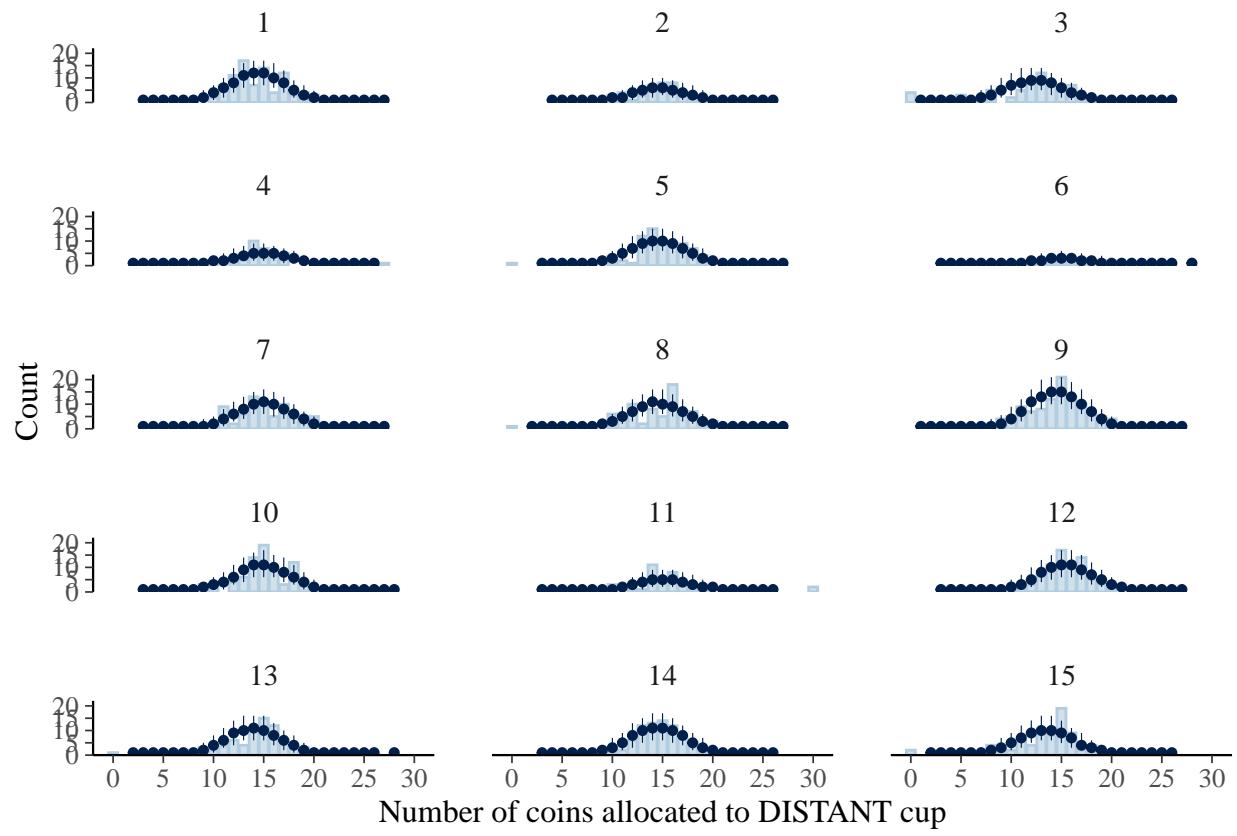


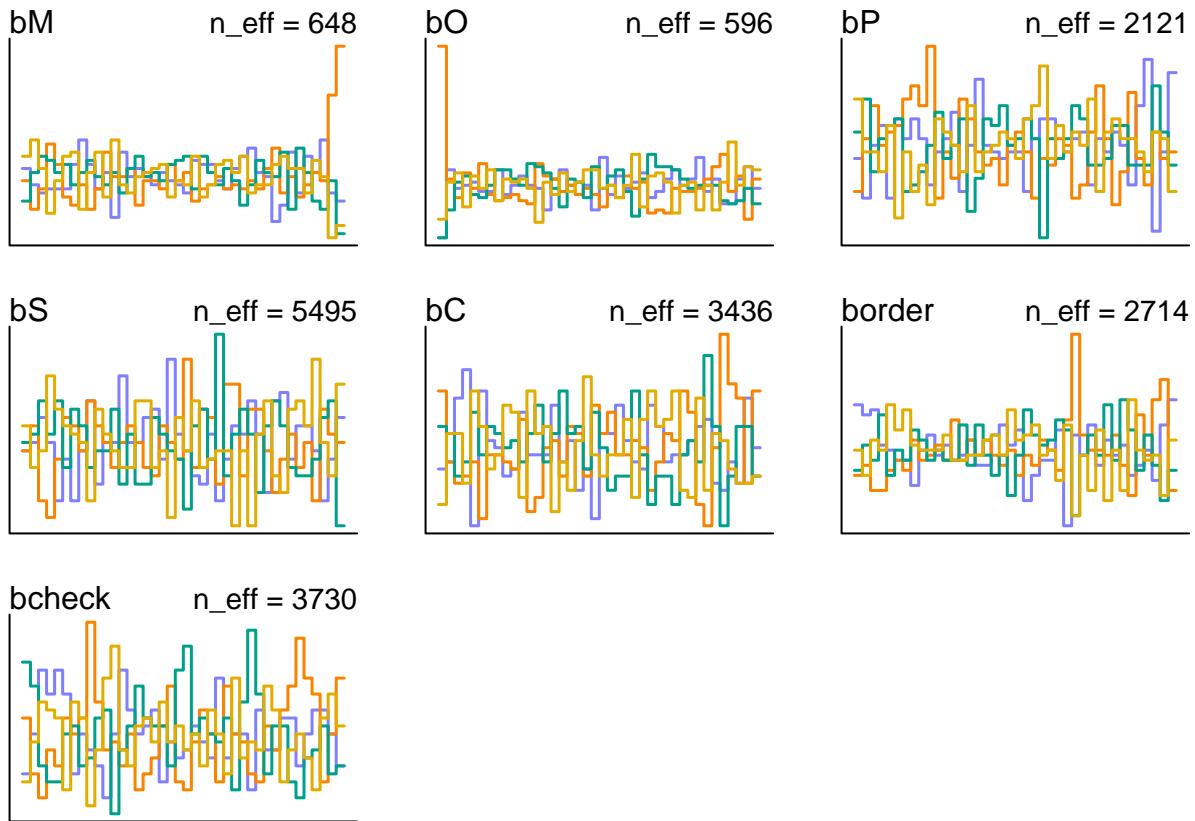


RAG SPEC LOCAL ADD

```
## Warning: 55 of 4000 (1.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```







```

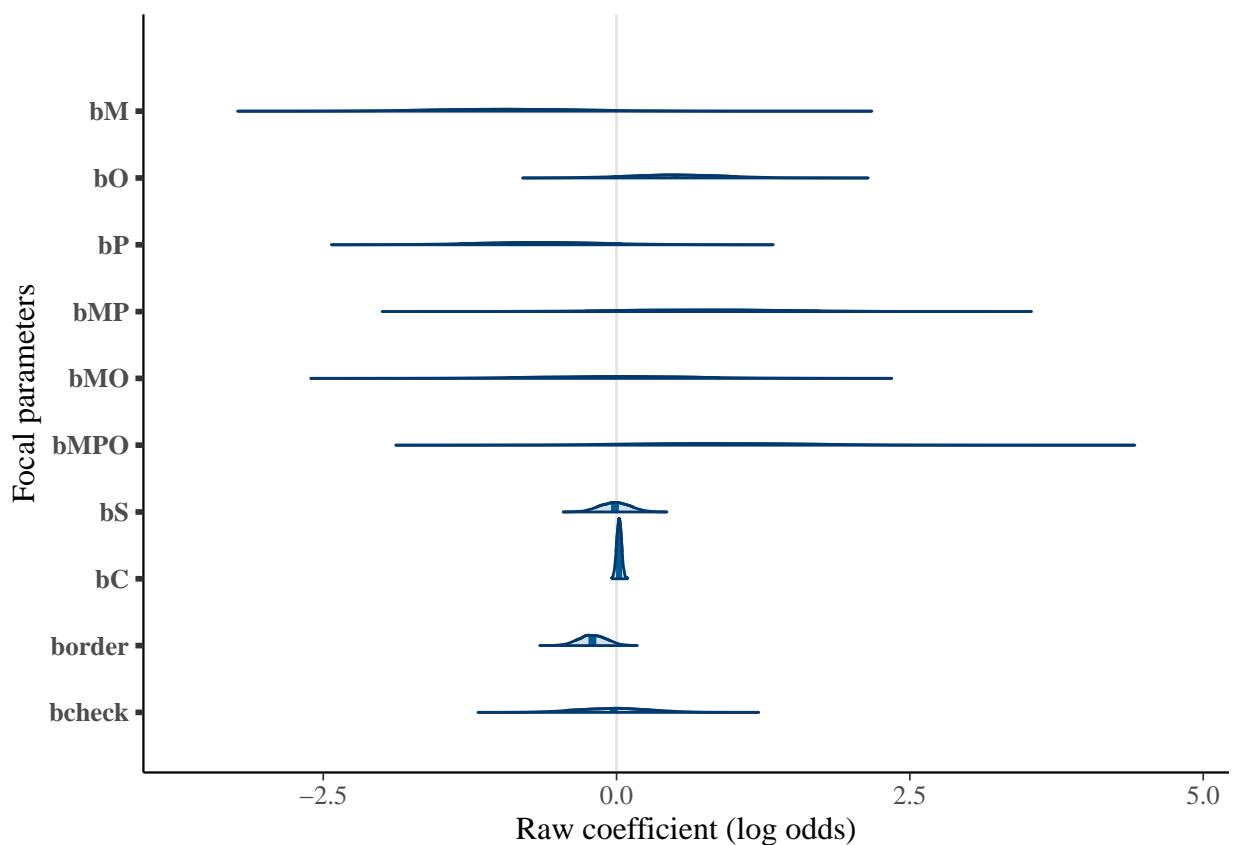
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

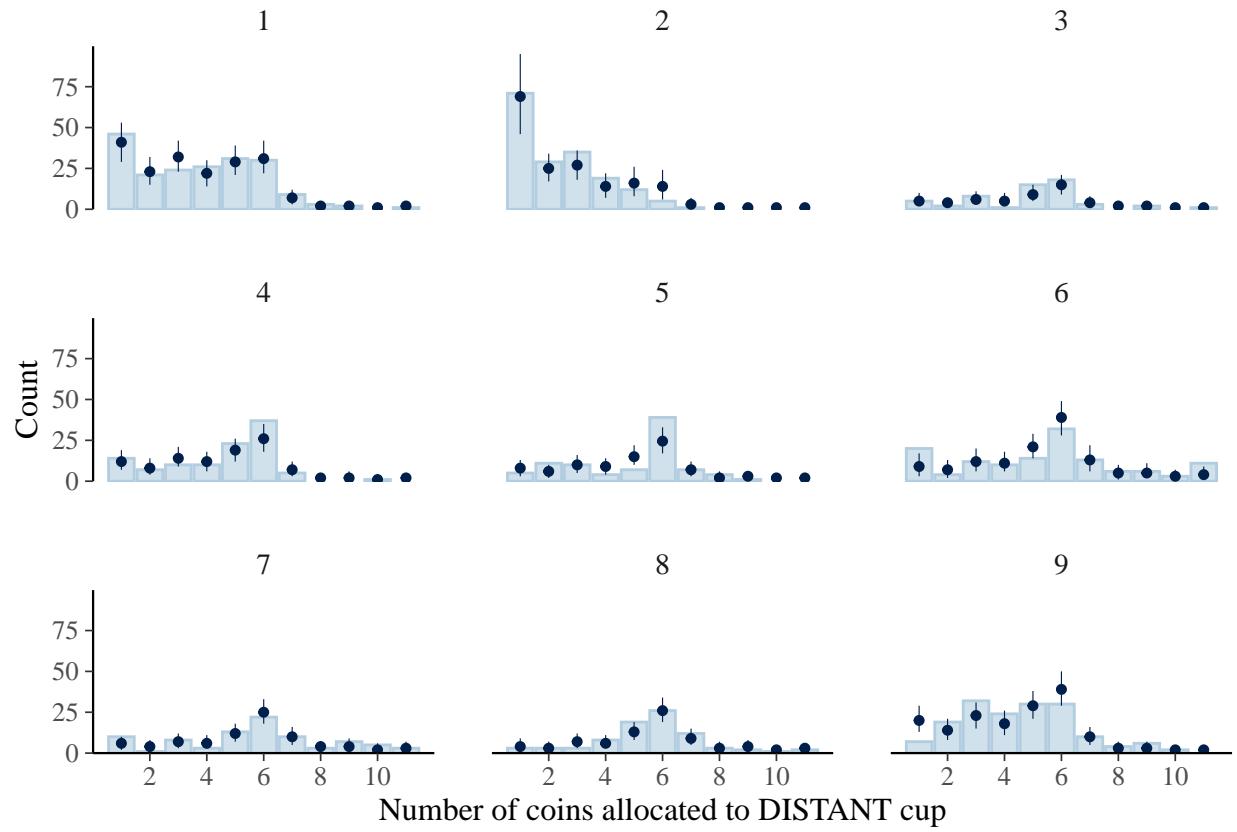
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.

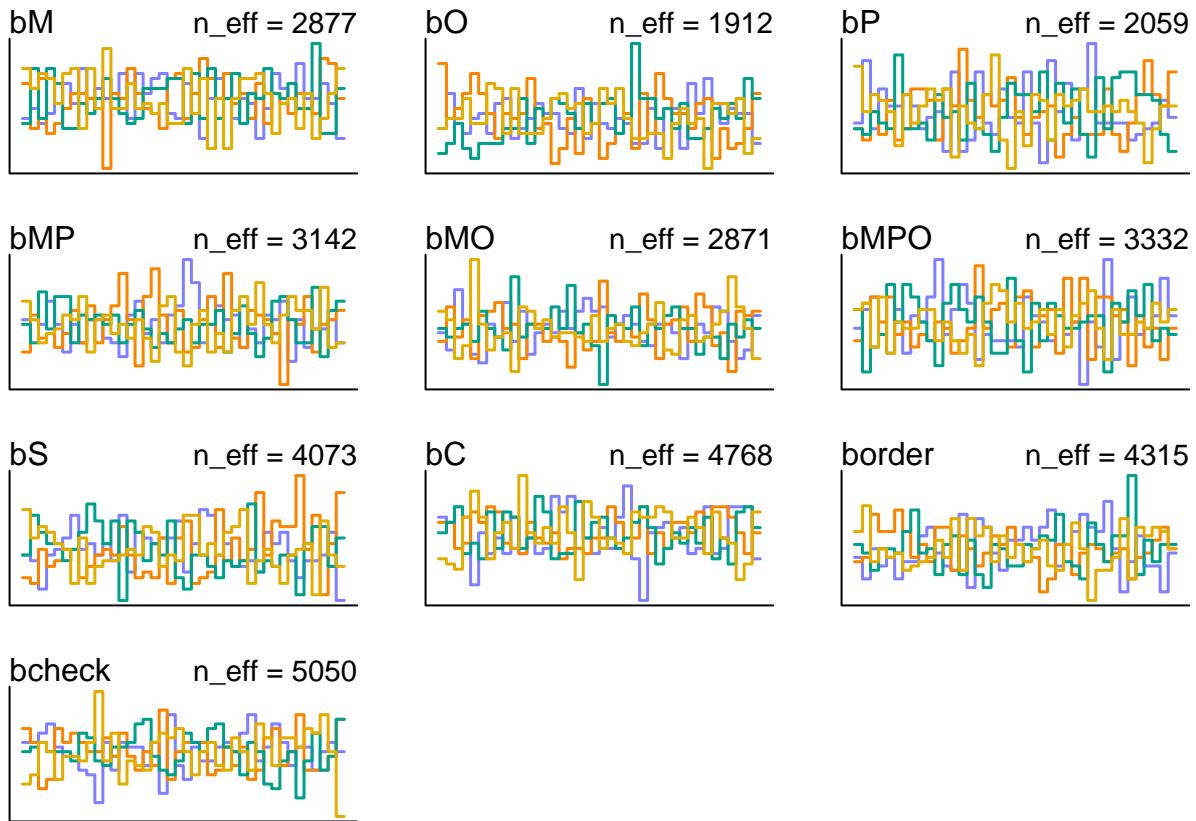
##           elpd_diff se_diff
## model2    0.0      0.0
## model1   -3.0     2.8

```

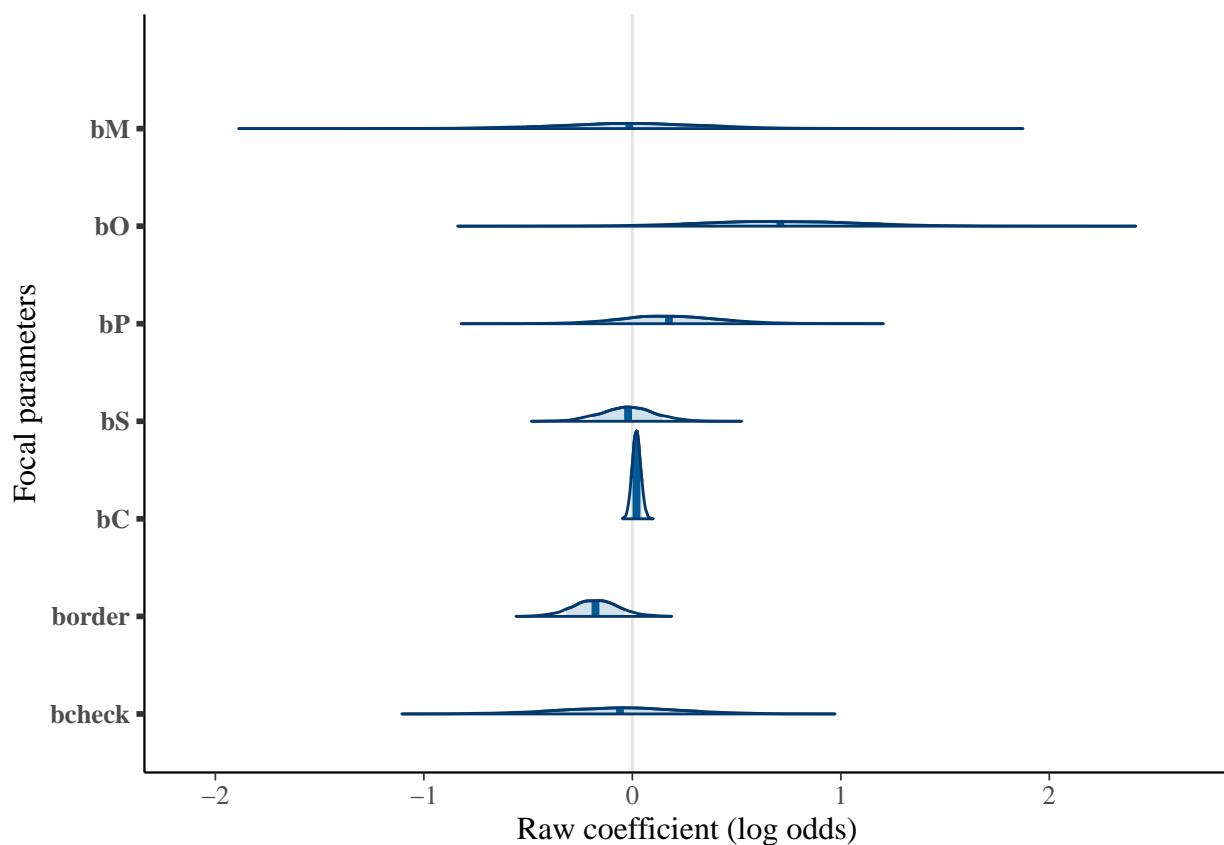
DG SPEC SELF INT

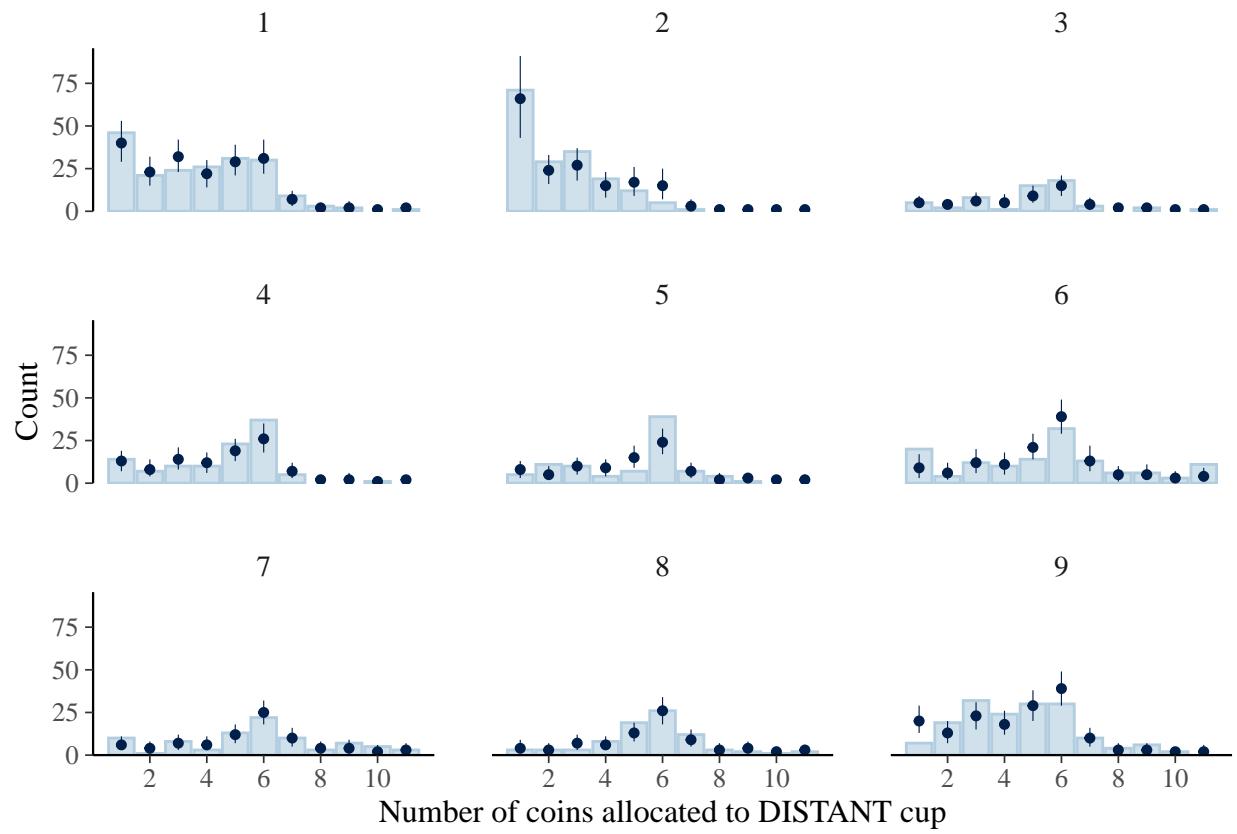


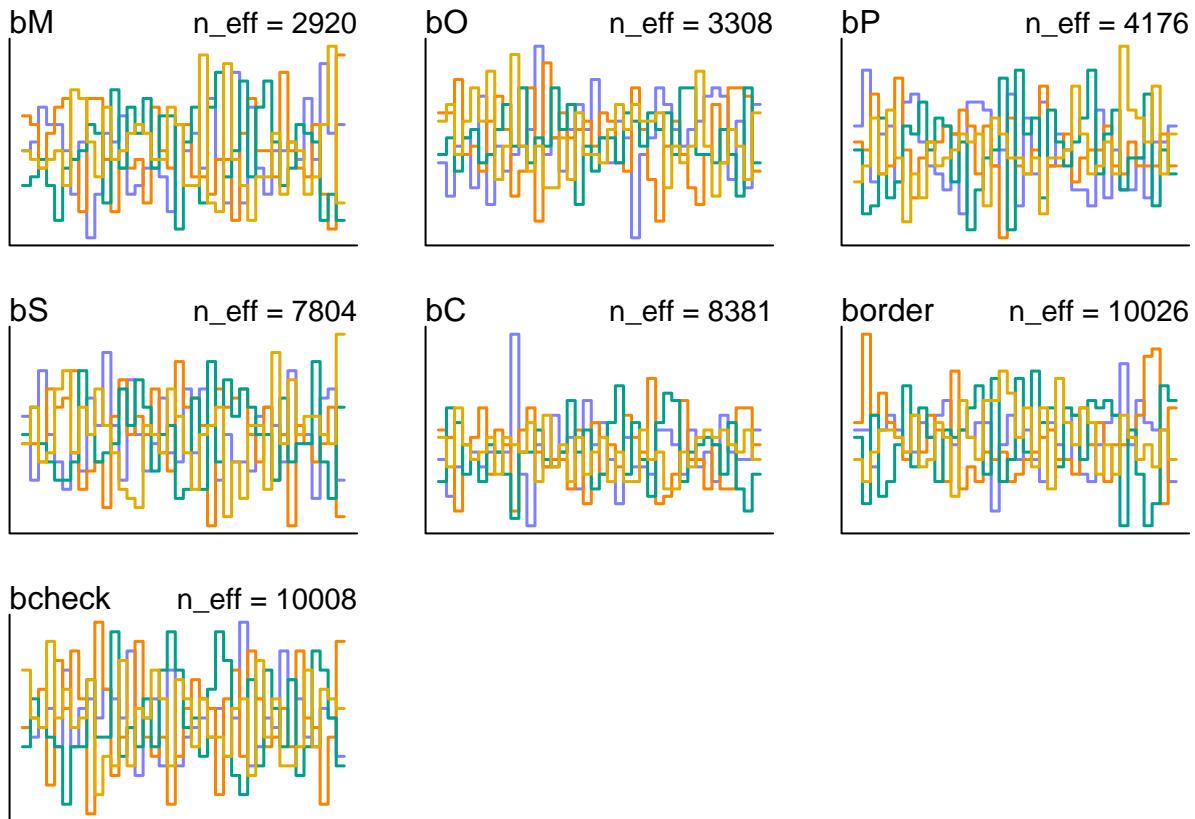




DG SPEC SELF ADD



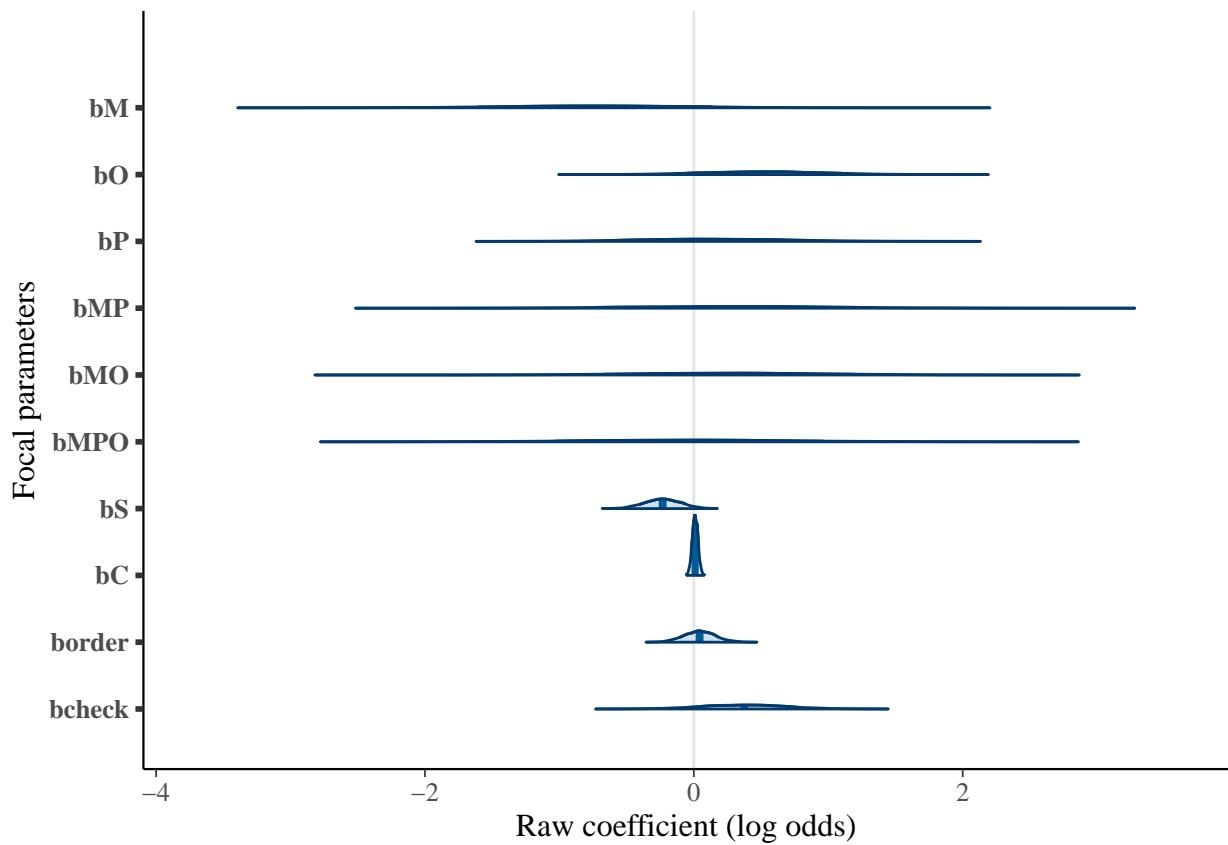


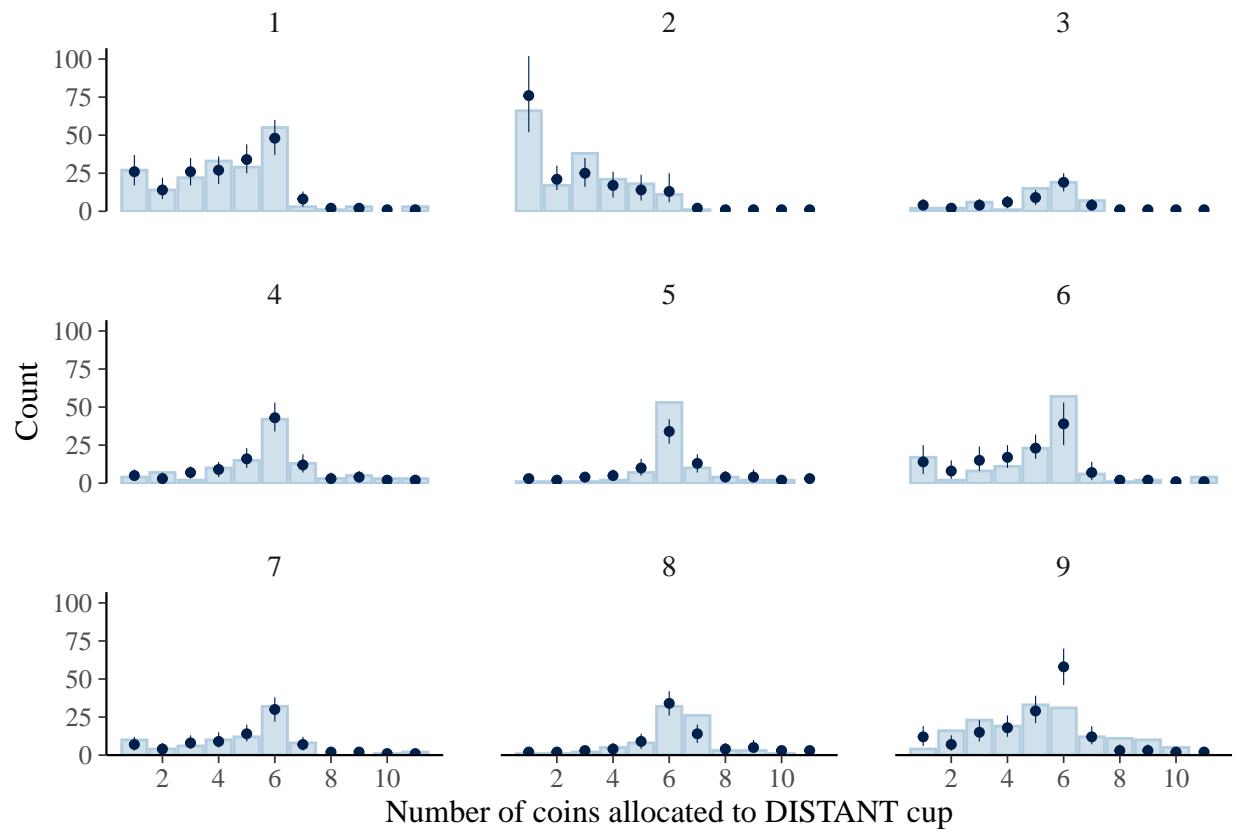


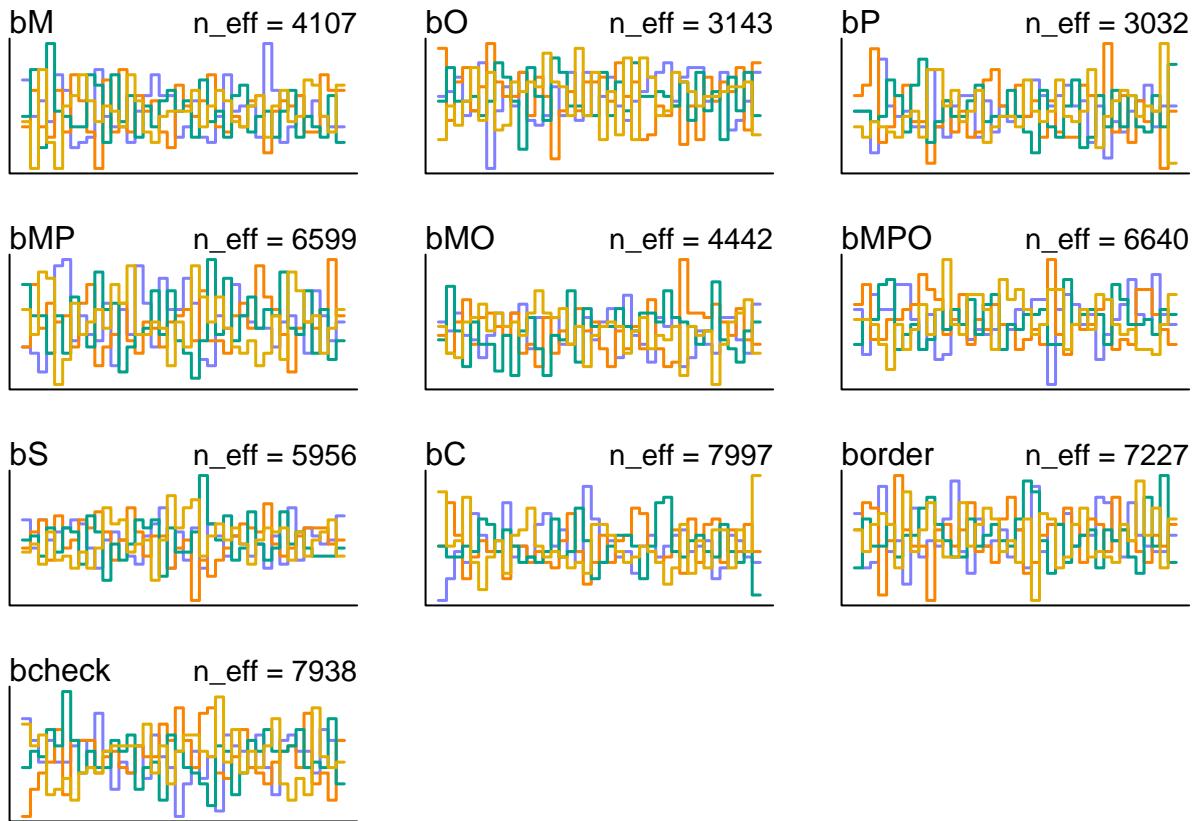
```
##          elpd_diff se_diff
## model1    0.0      0.0
## model2 -2.7     2.7
```

DG SPEC LOCAL INT

```
## Warning: 1 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```

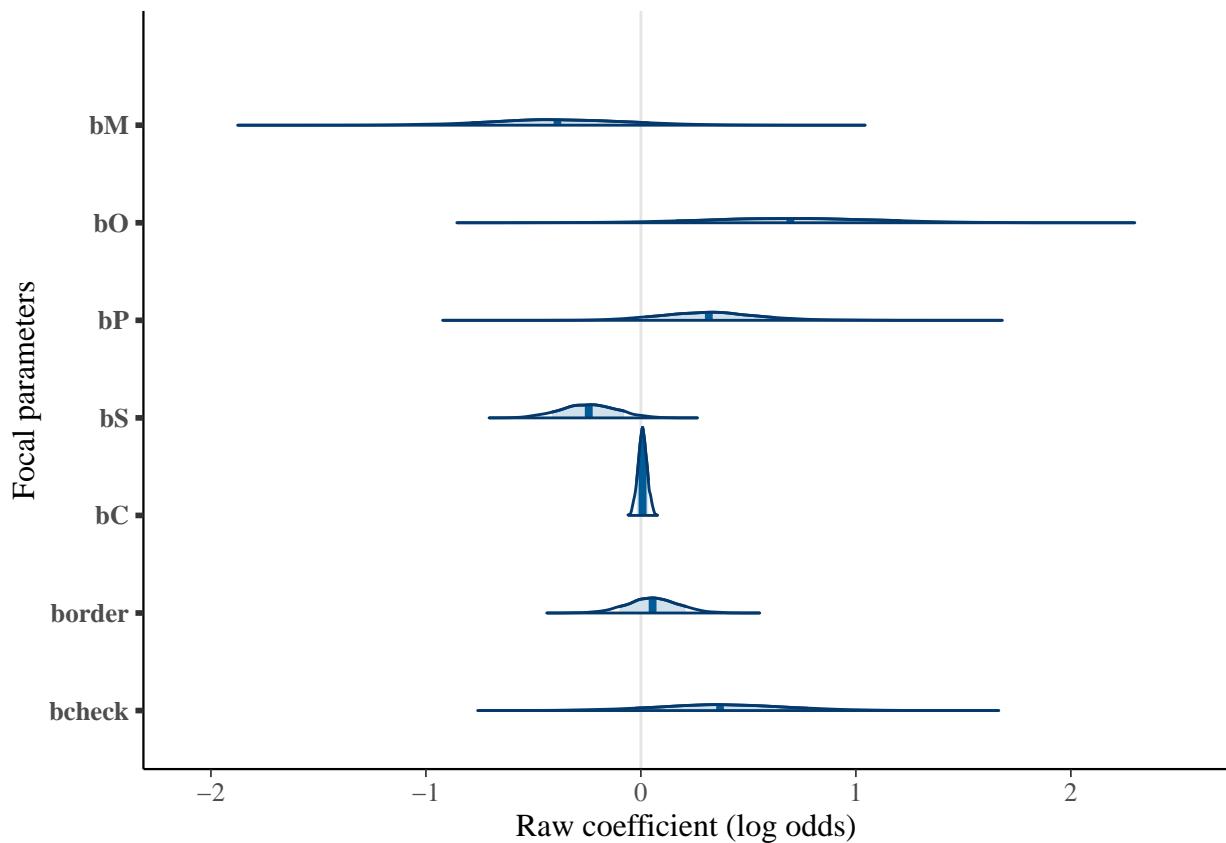


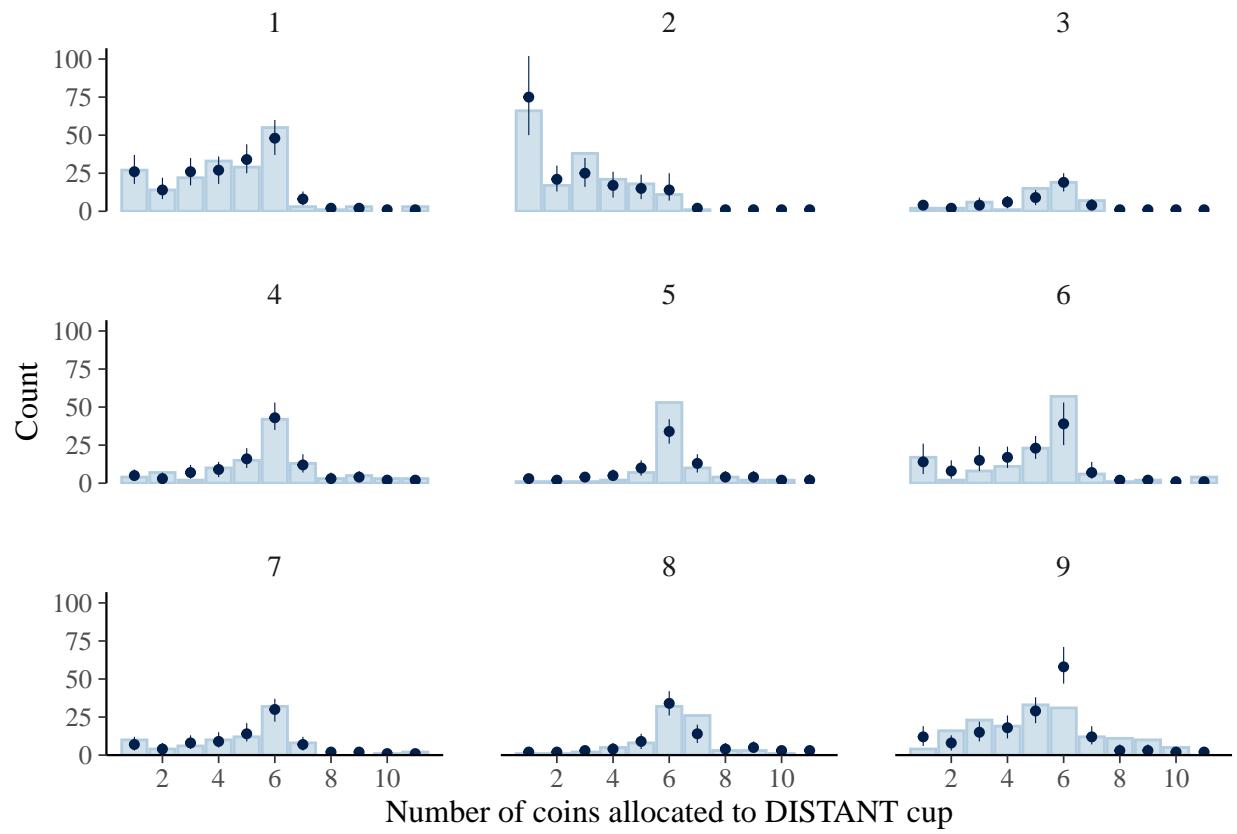


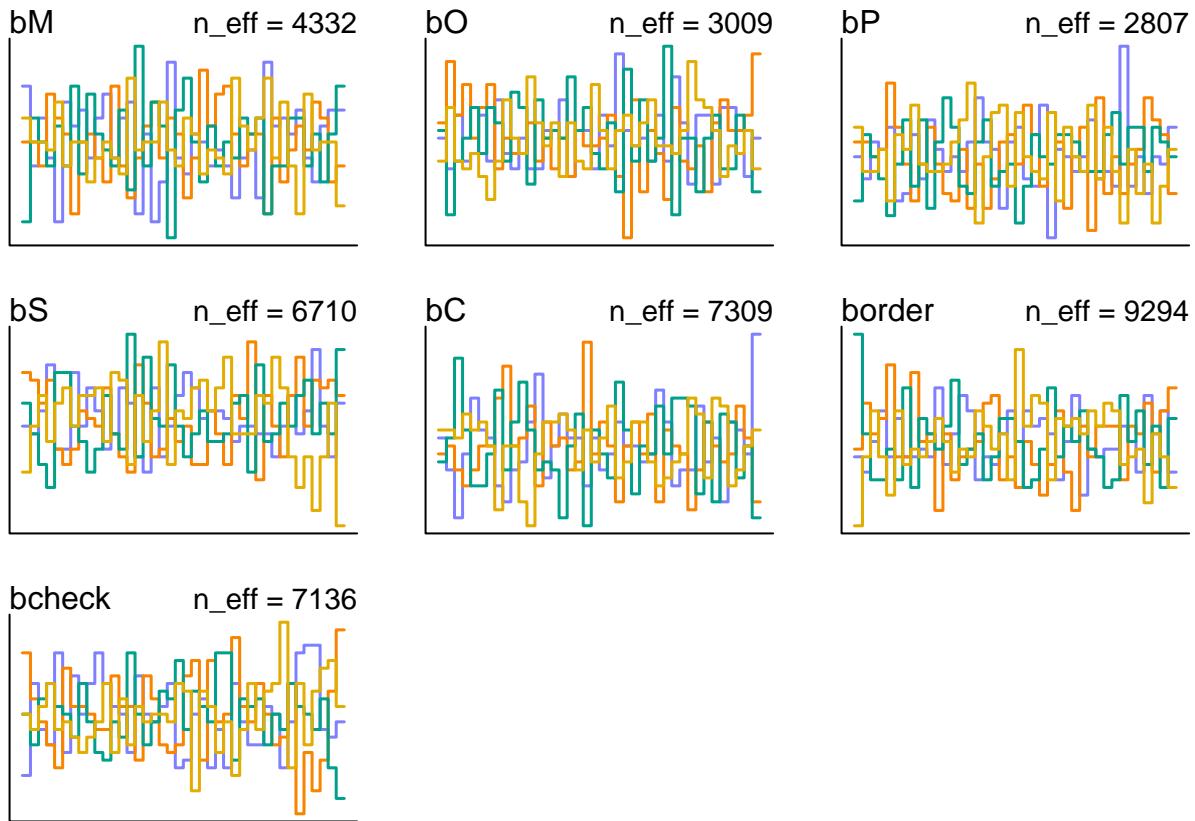


DG SPEC LOCAL ADD

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## Warning: 1 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```

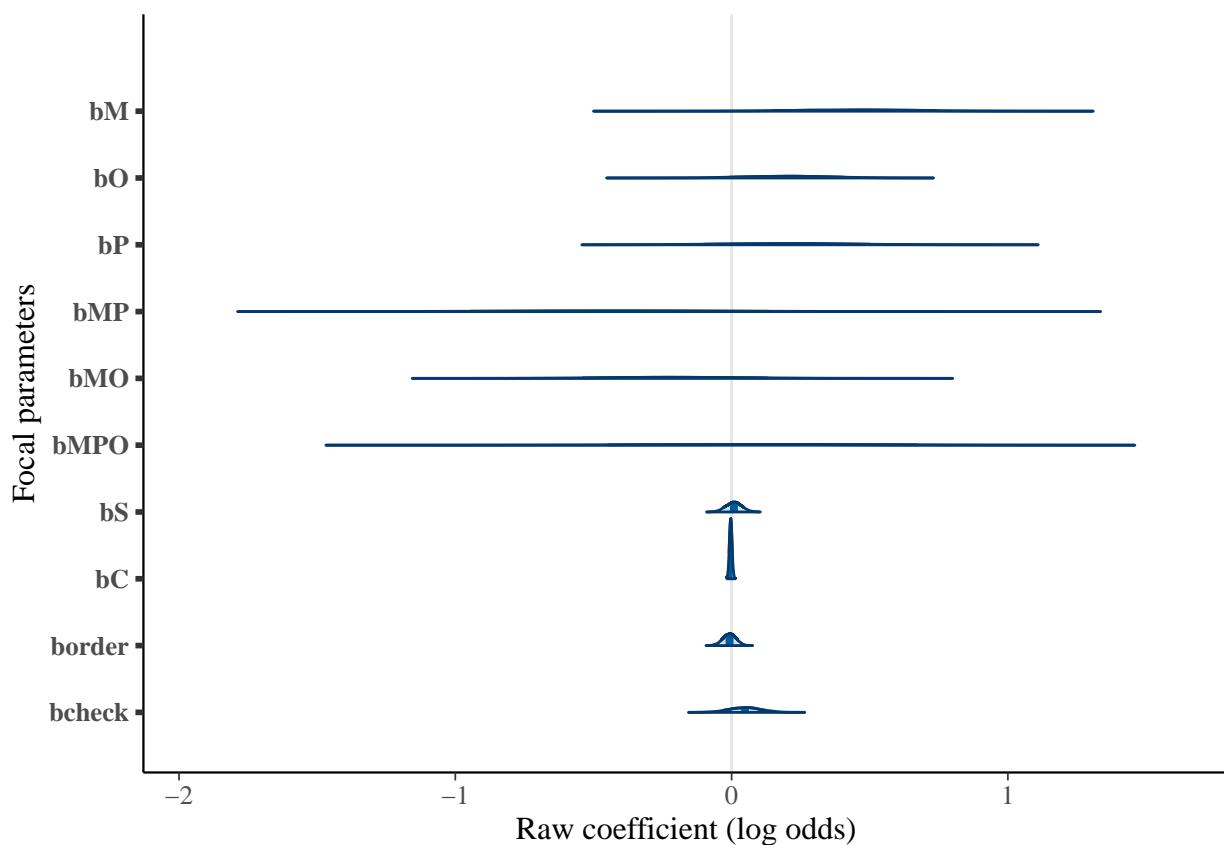


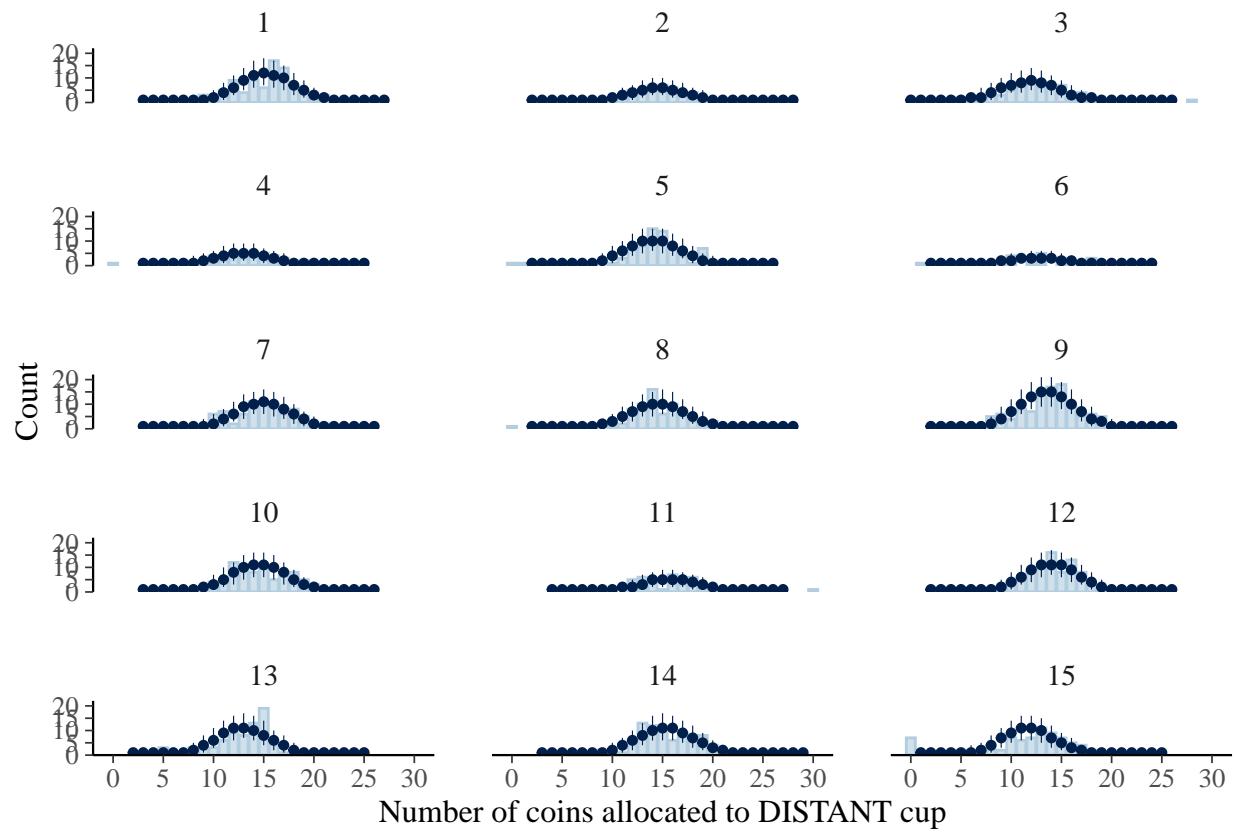


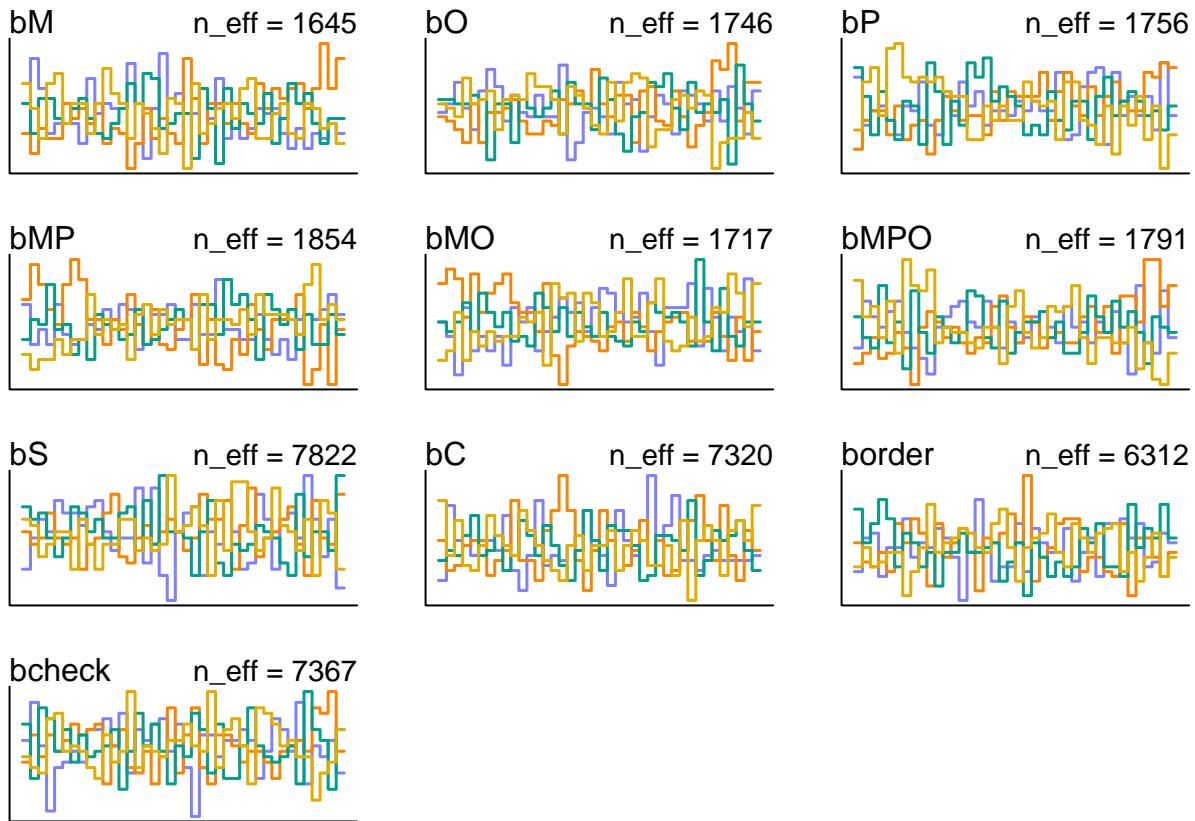


```
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -2.4     1.4
```

RAG MV SELF INT

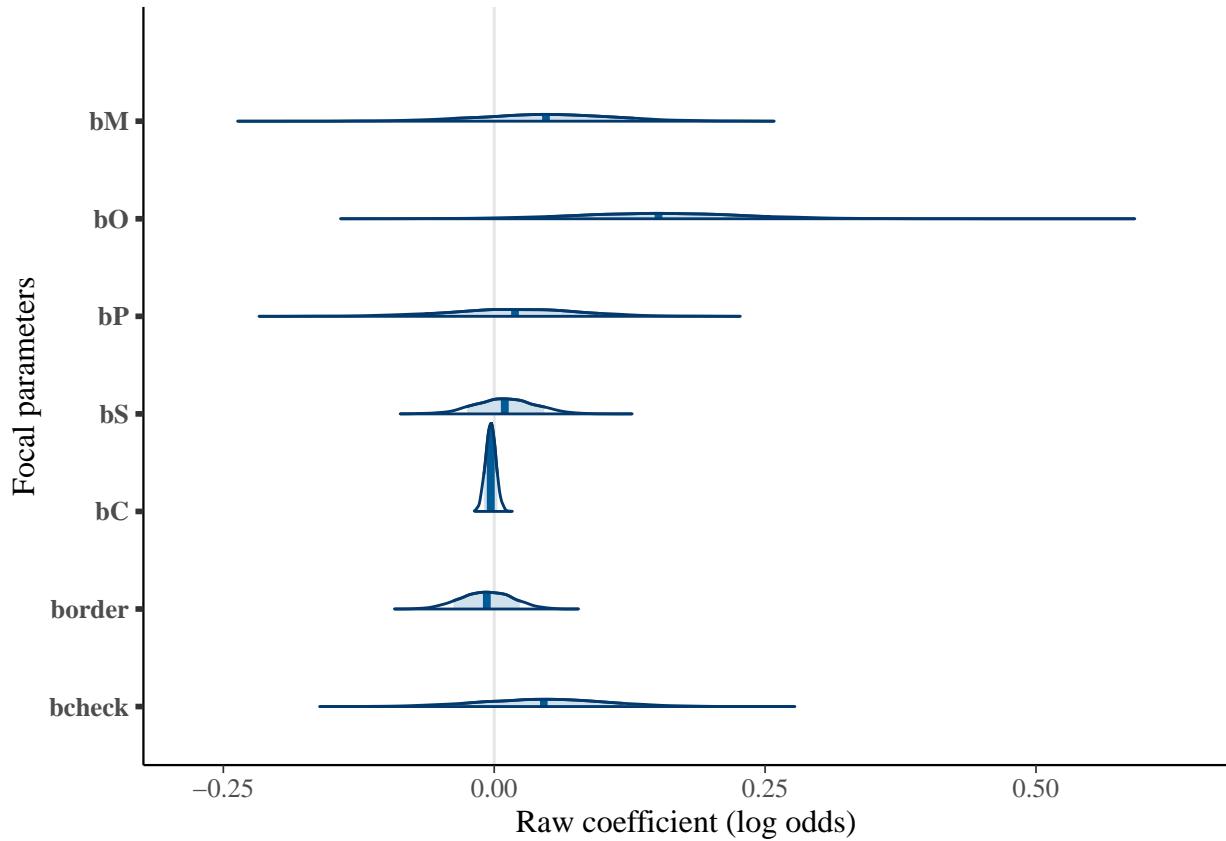


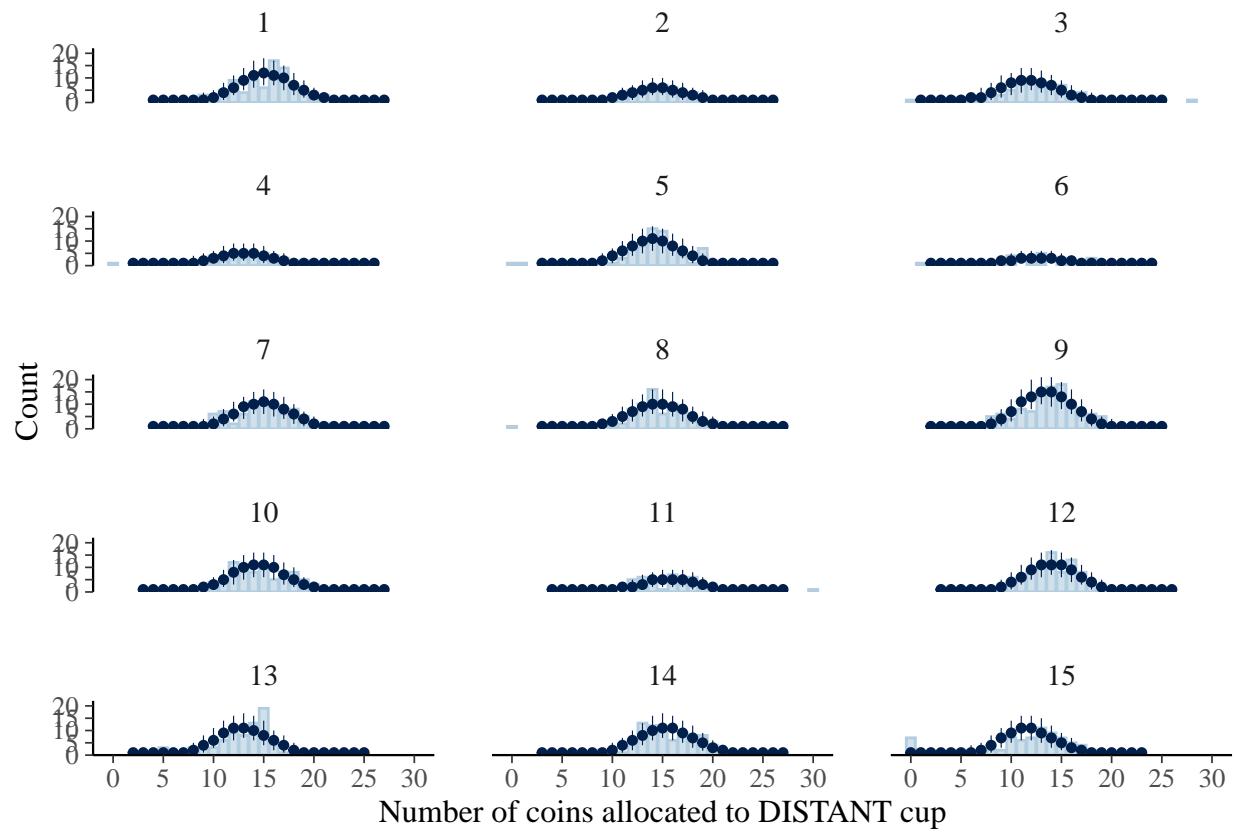


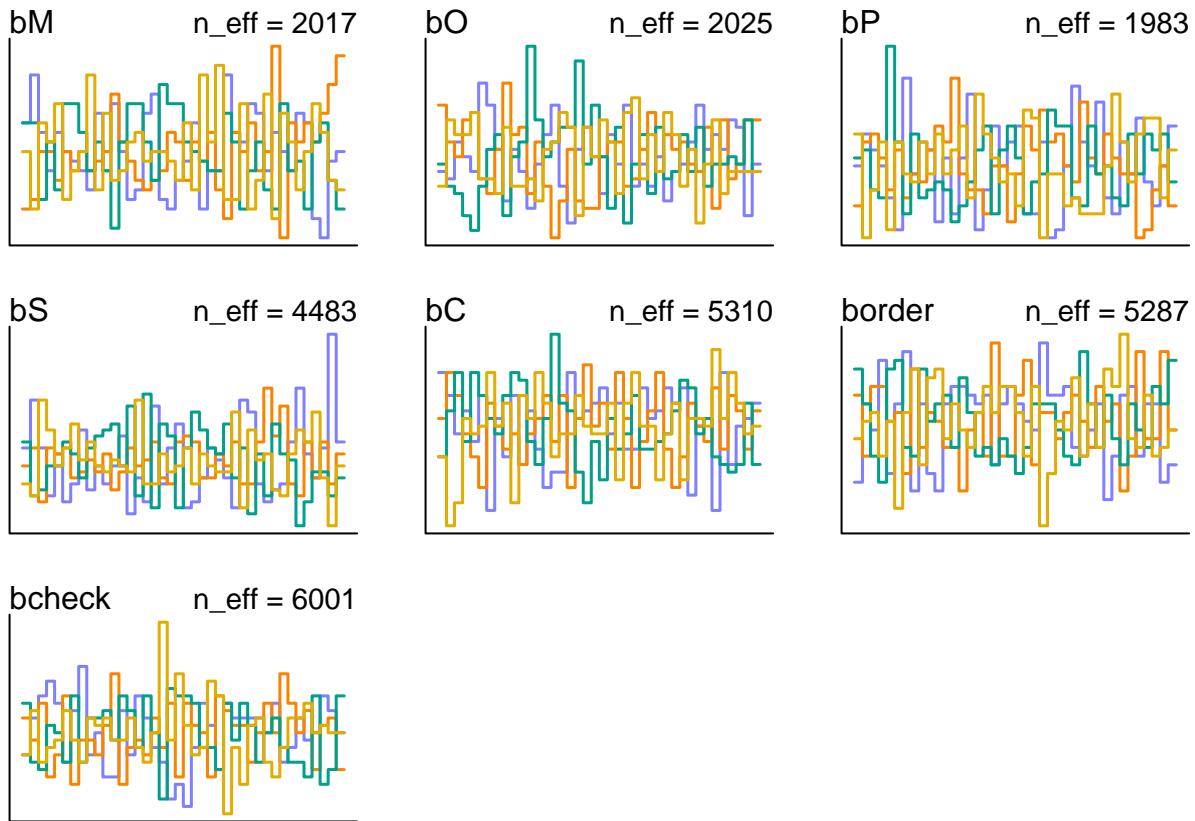


RAG MV SELF ADD

```
## Warning: 13 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```





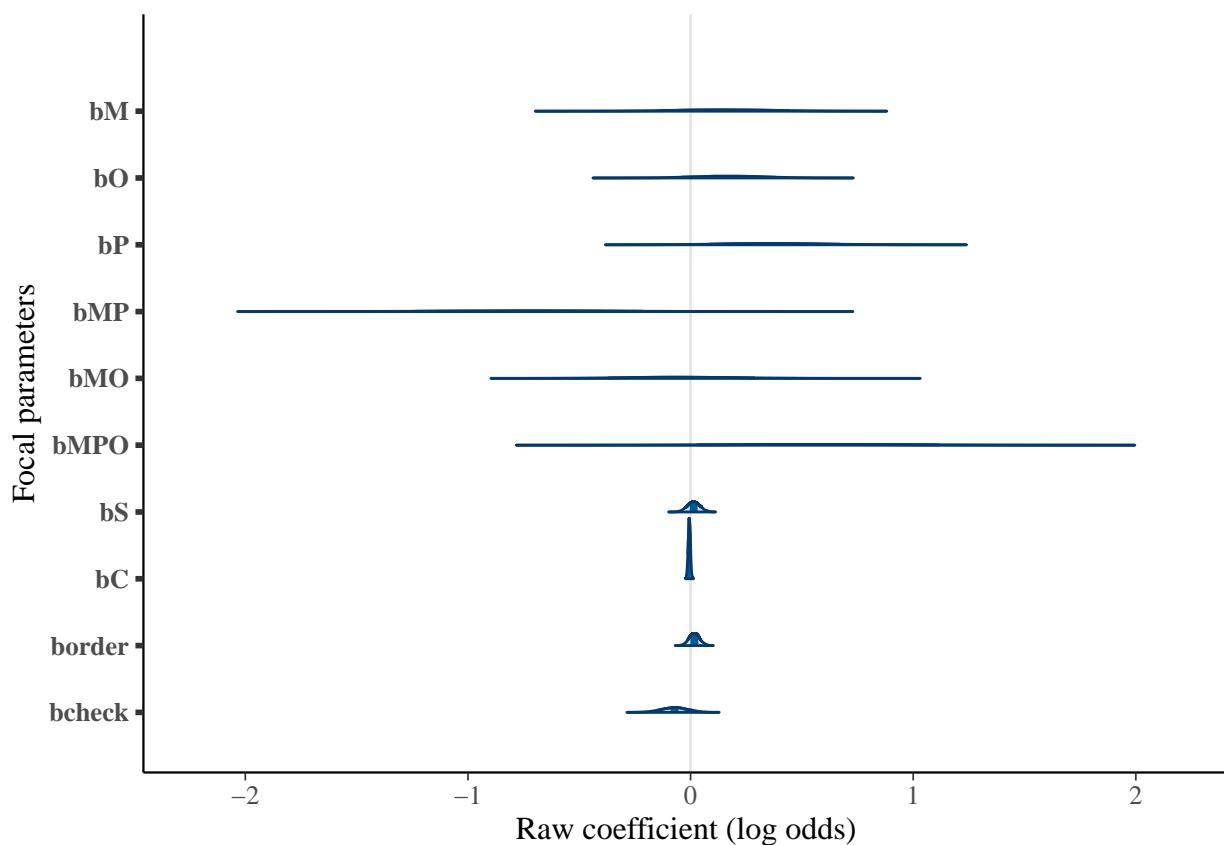


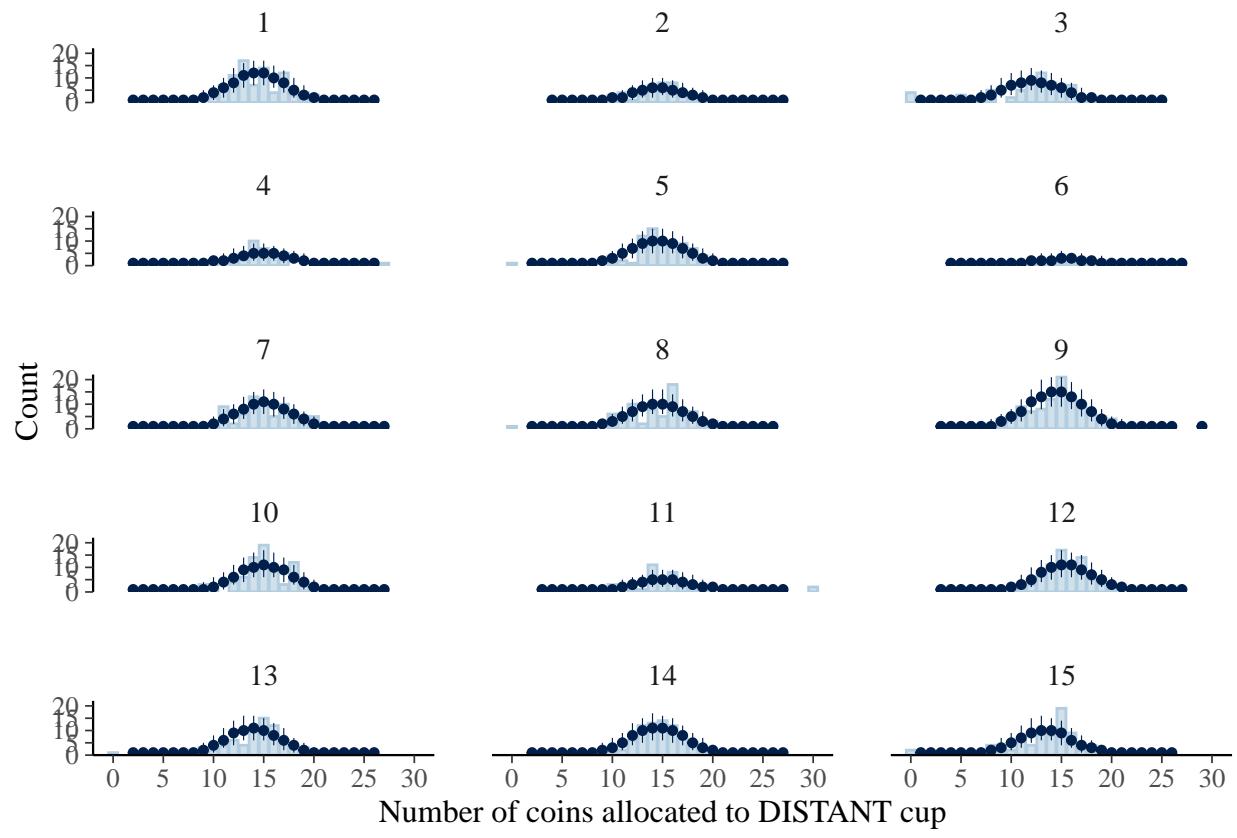
```

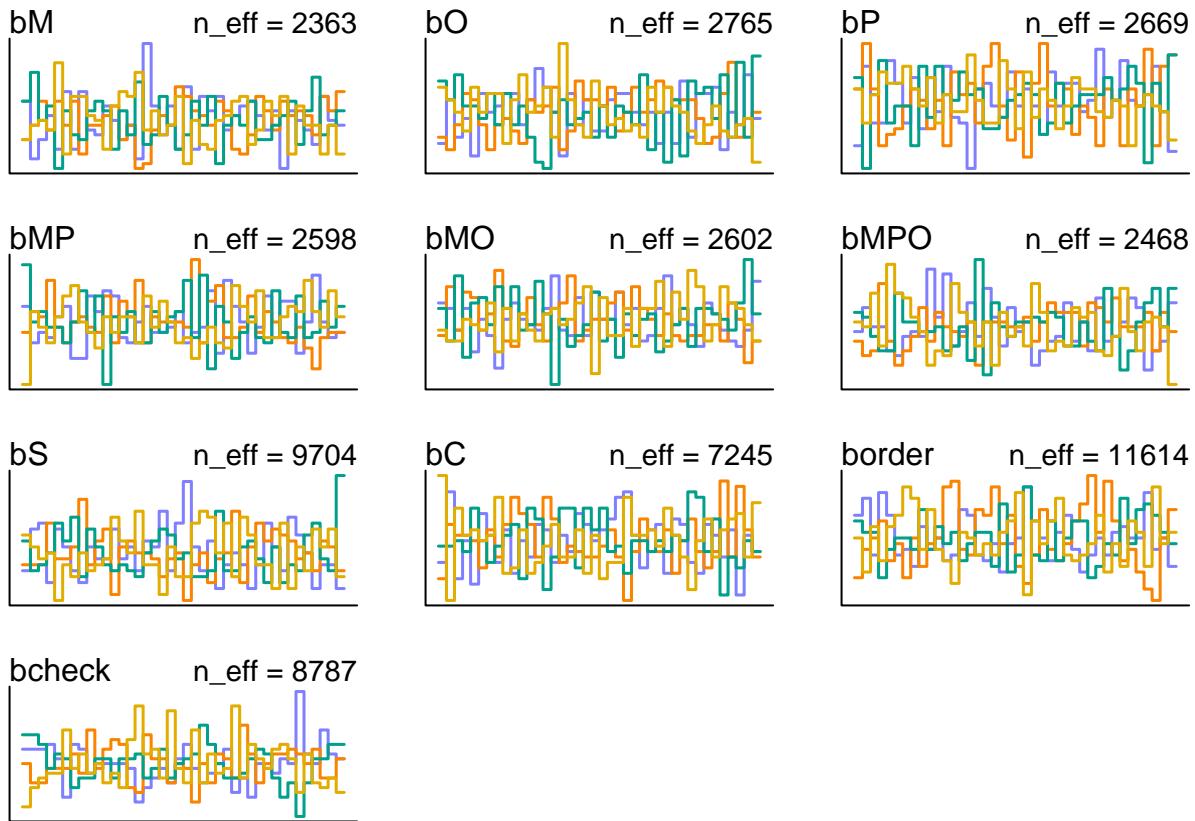
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -3.6     4.4

```

RAG MV LOCAL INT

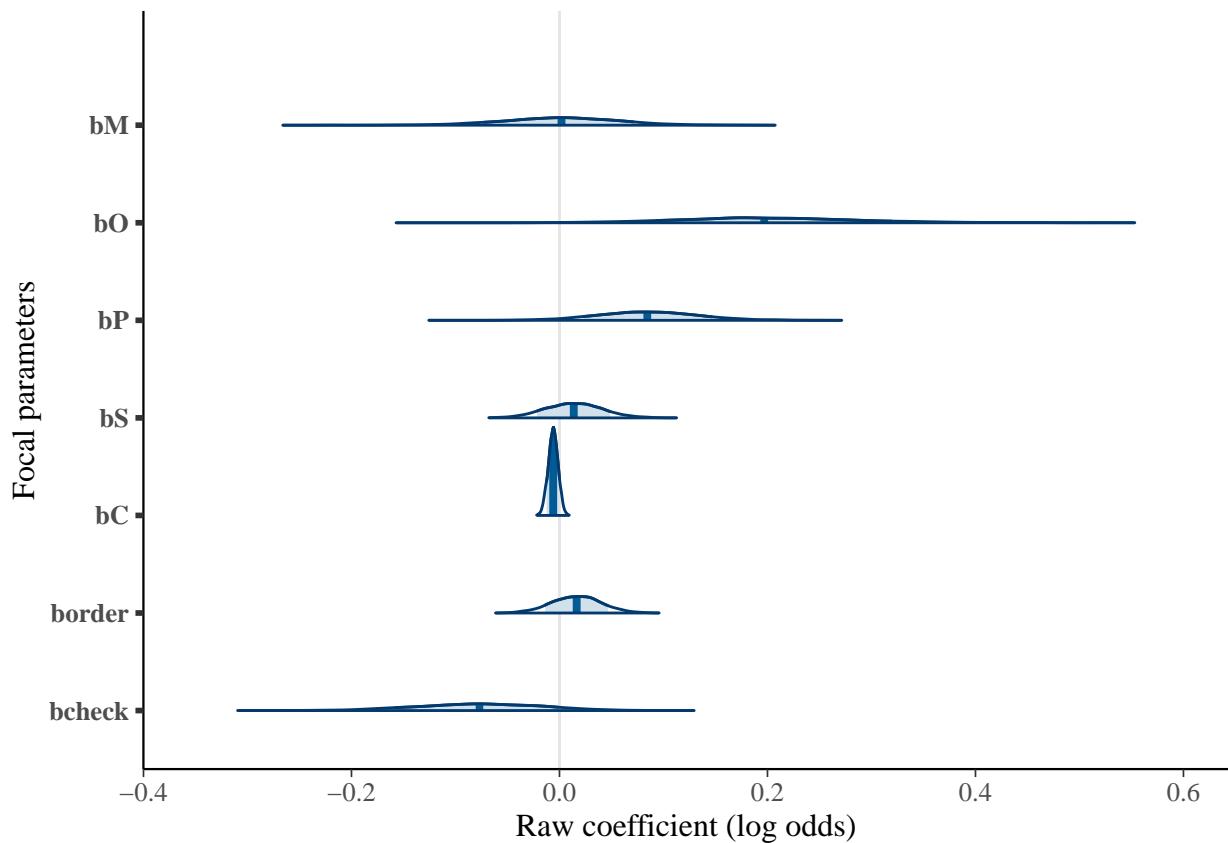


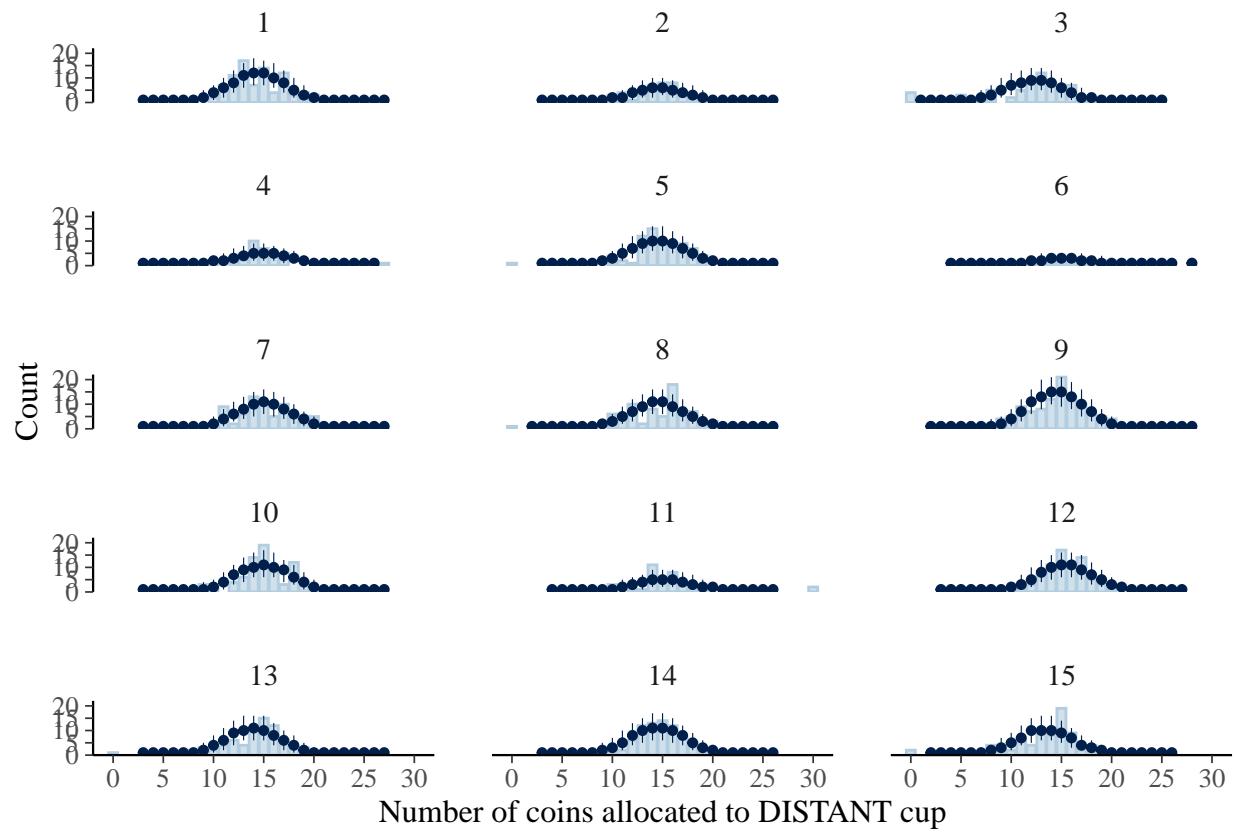


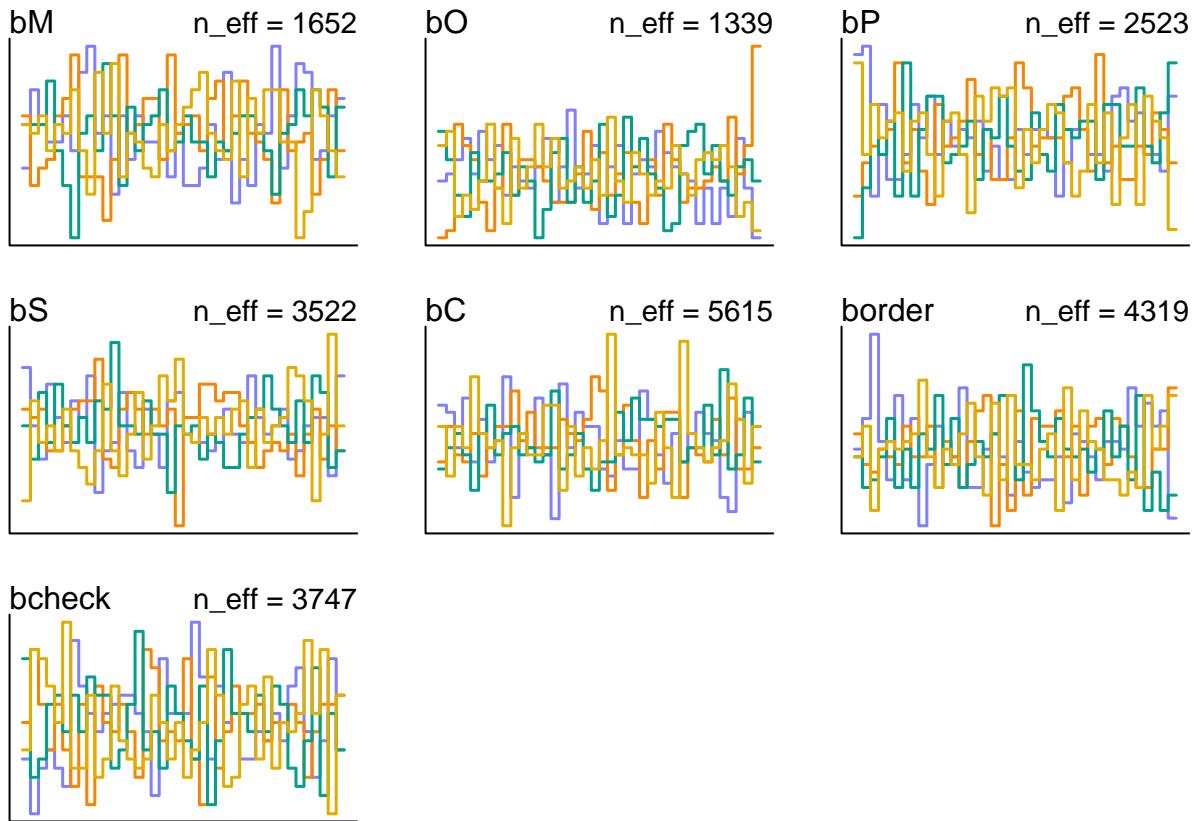


RAG MV LOCAL ADD

```
## Warning: 15 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```





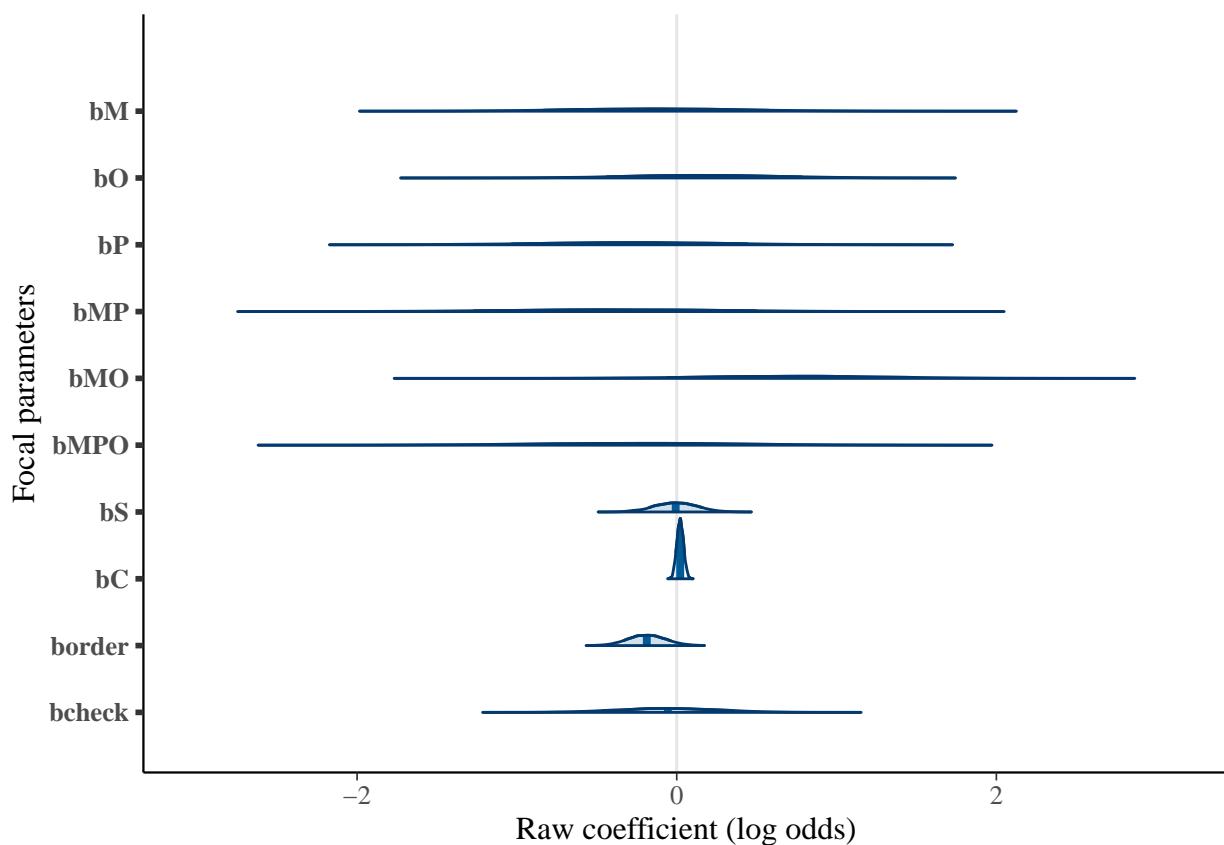


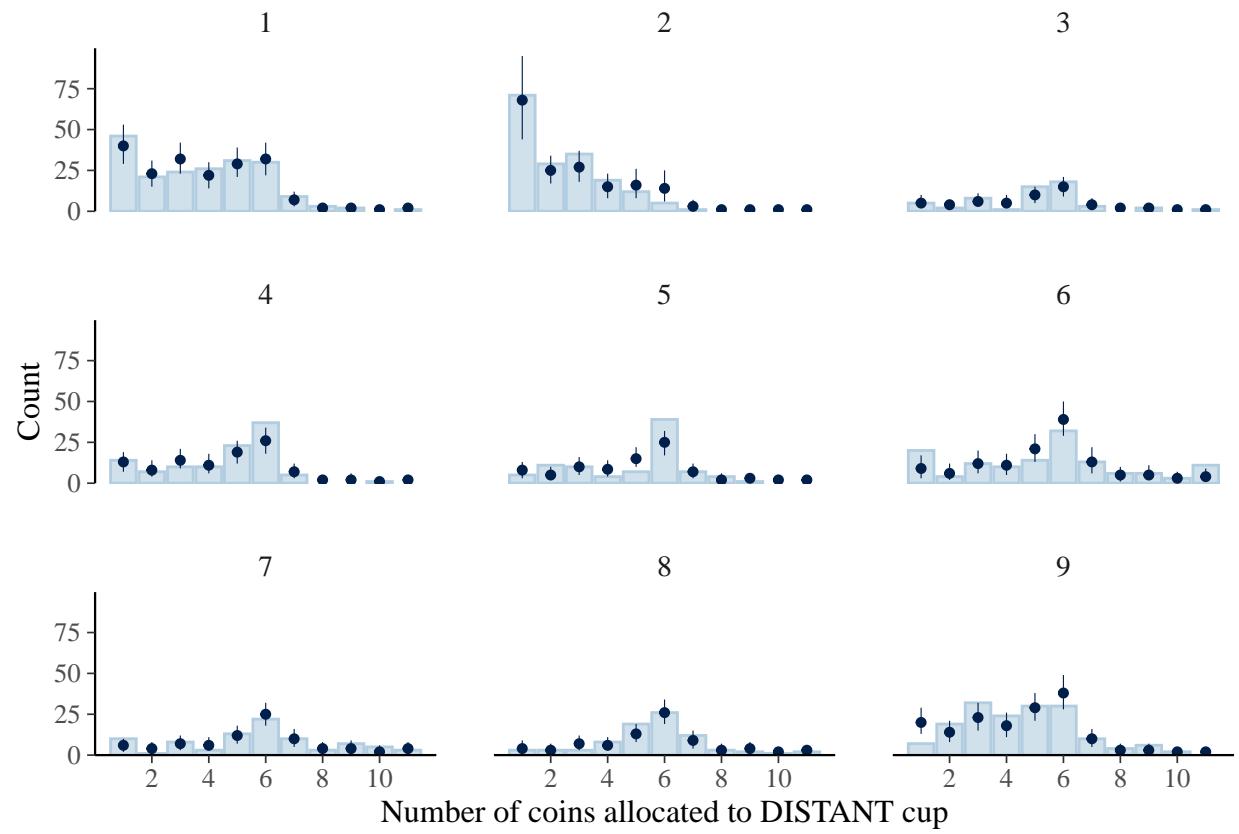
```

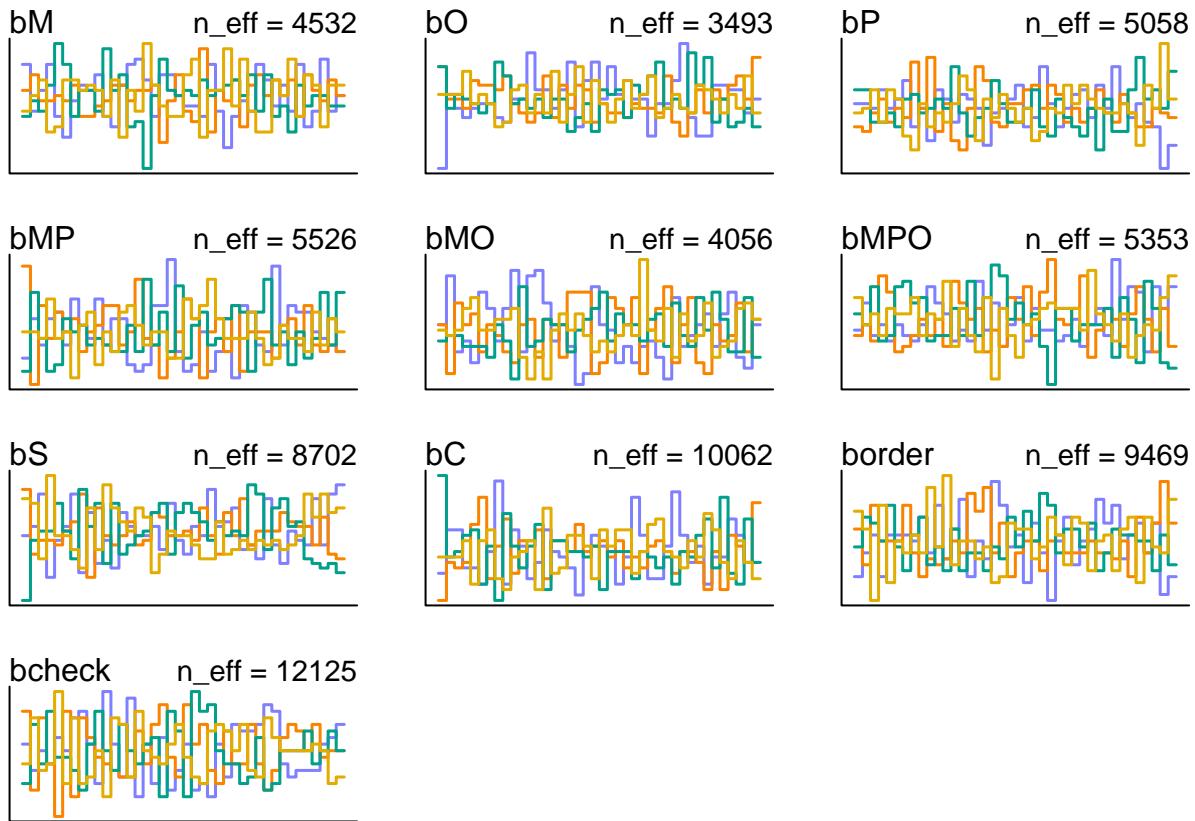
## Warning: Some Pareto k diagnostic values are too high. See help('pareto-k-diagnostic') for details.
## Warning: Some Pareto k diagnostic values are slightly high. See help('pareto-k-diagnostic') for details
##          elpd_diff se_diff
## model2    0.0      0.0
## model1   -3.5     3.9

```

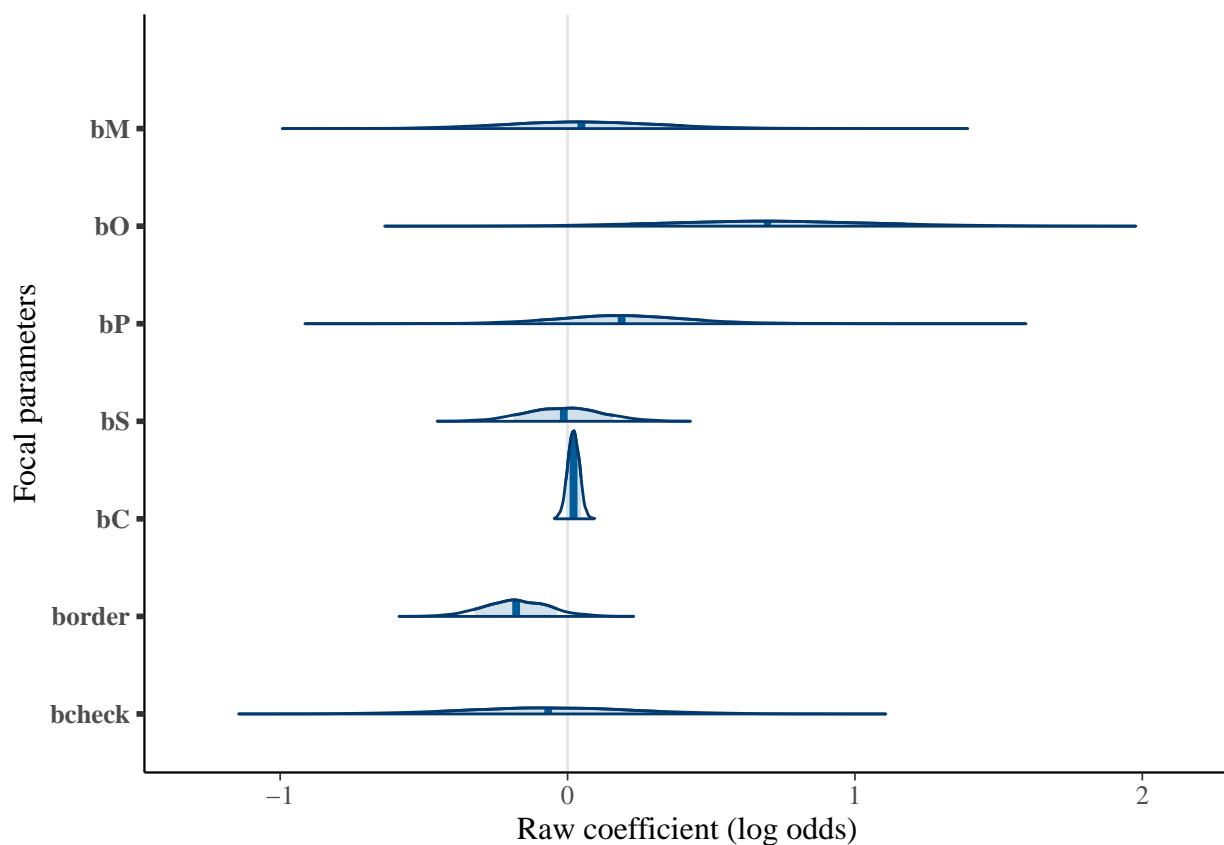
DG MV SELF INT

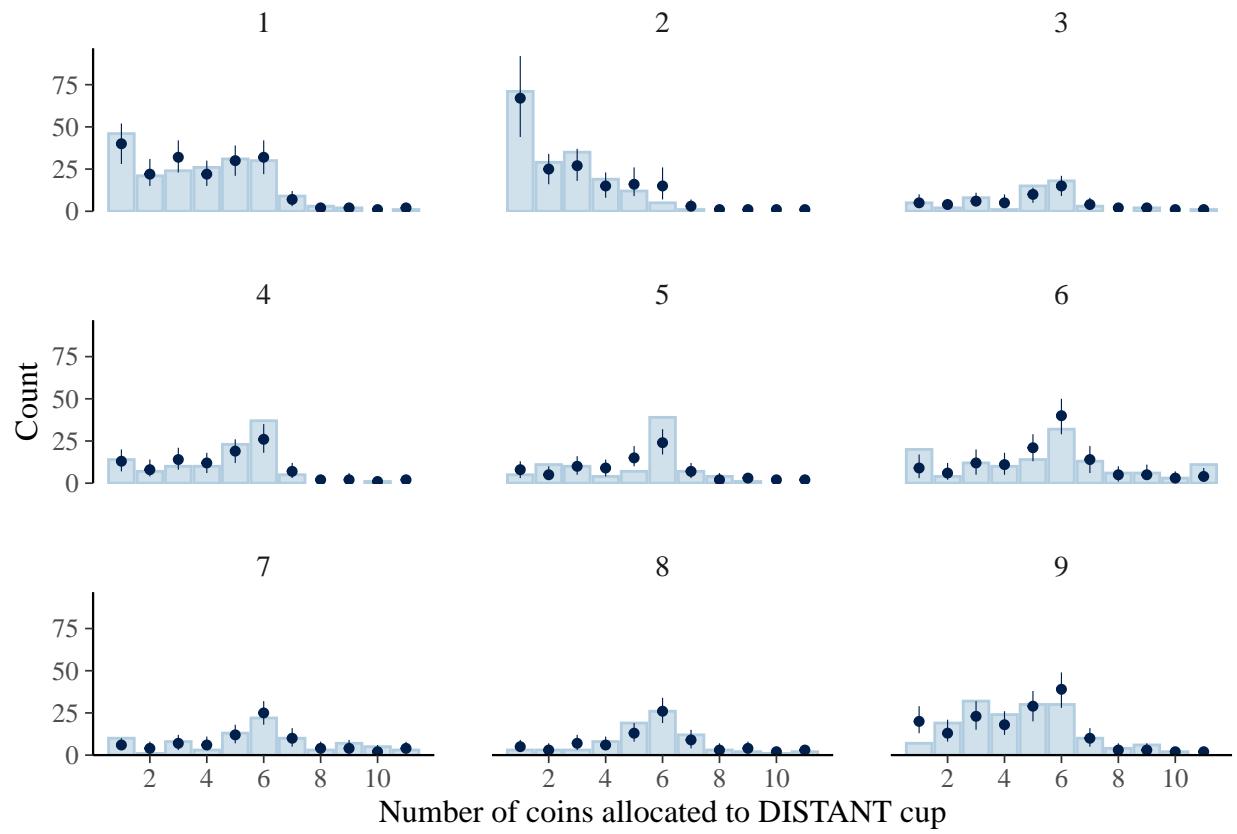


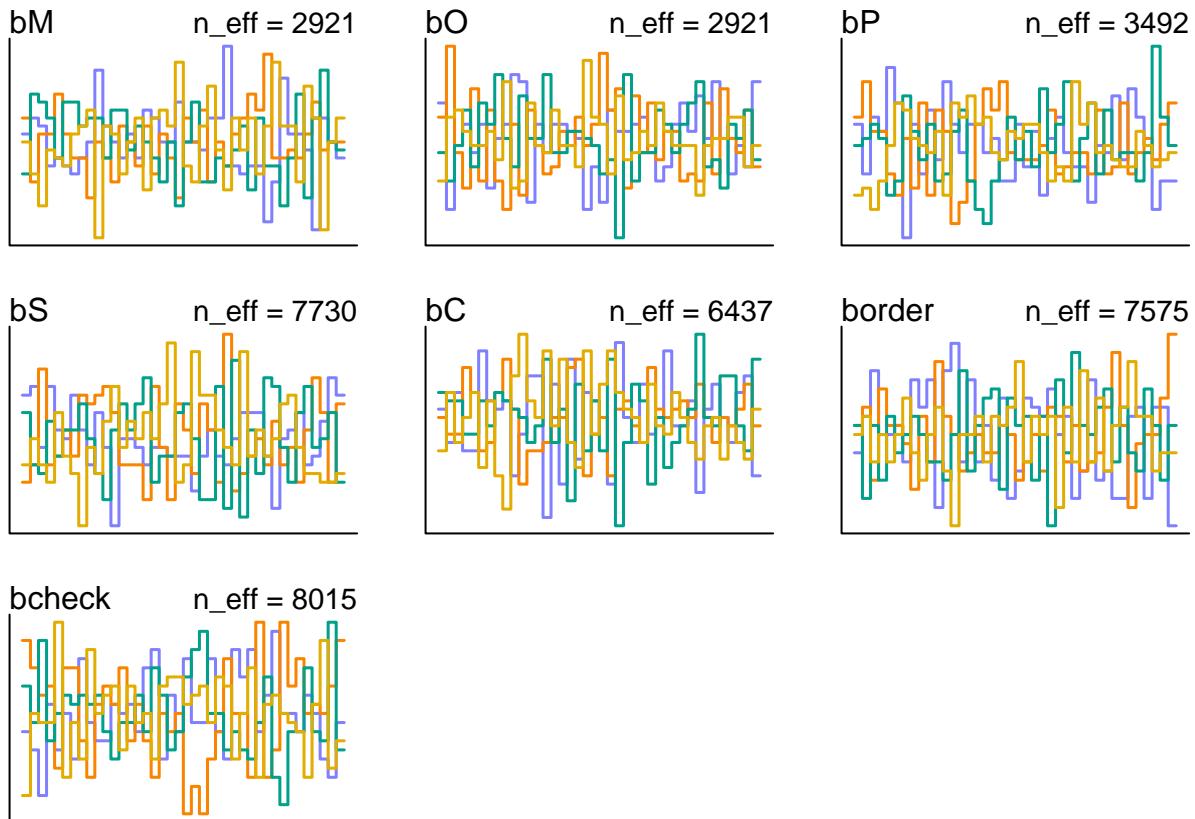




DG MV SELF ADD



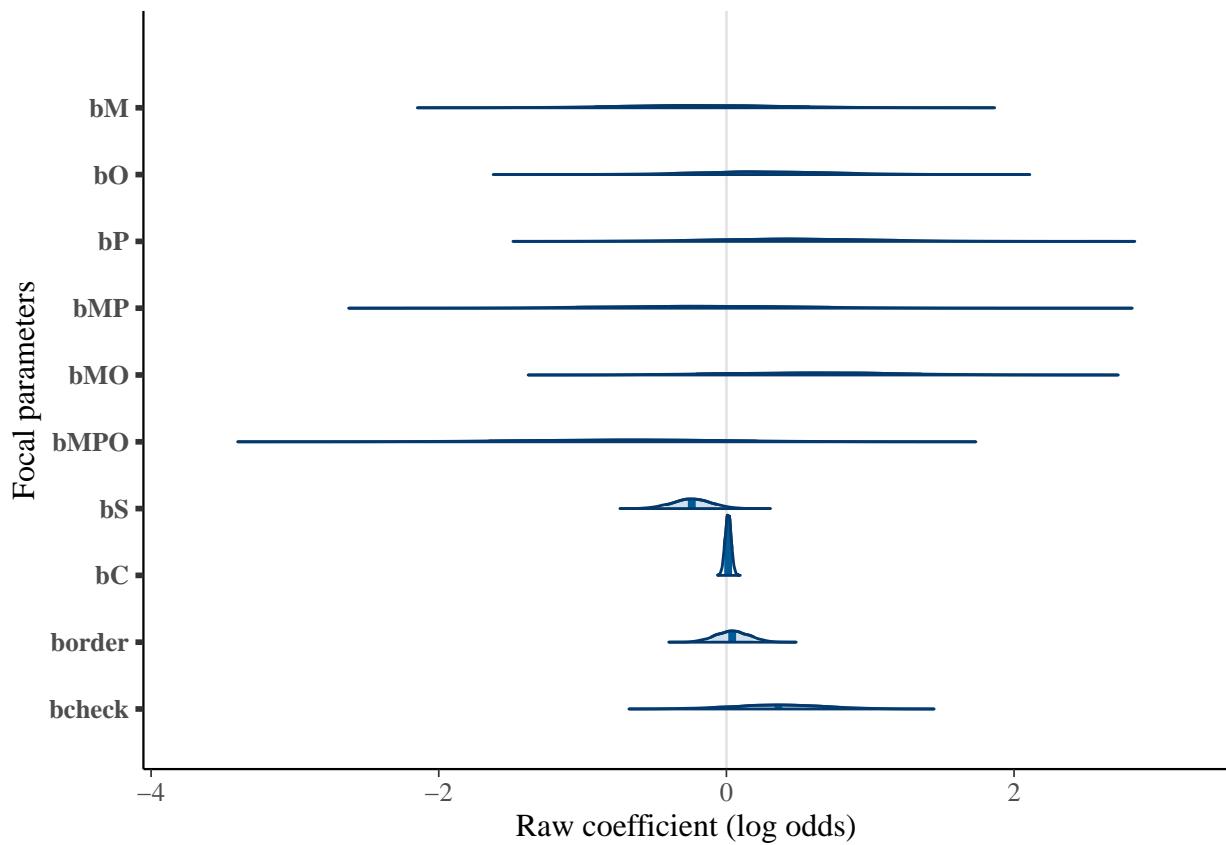


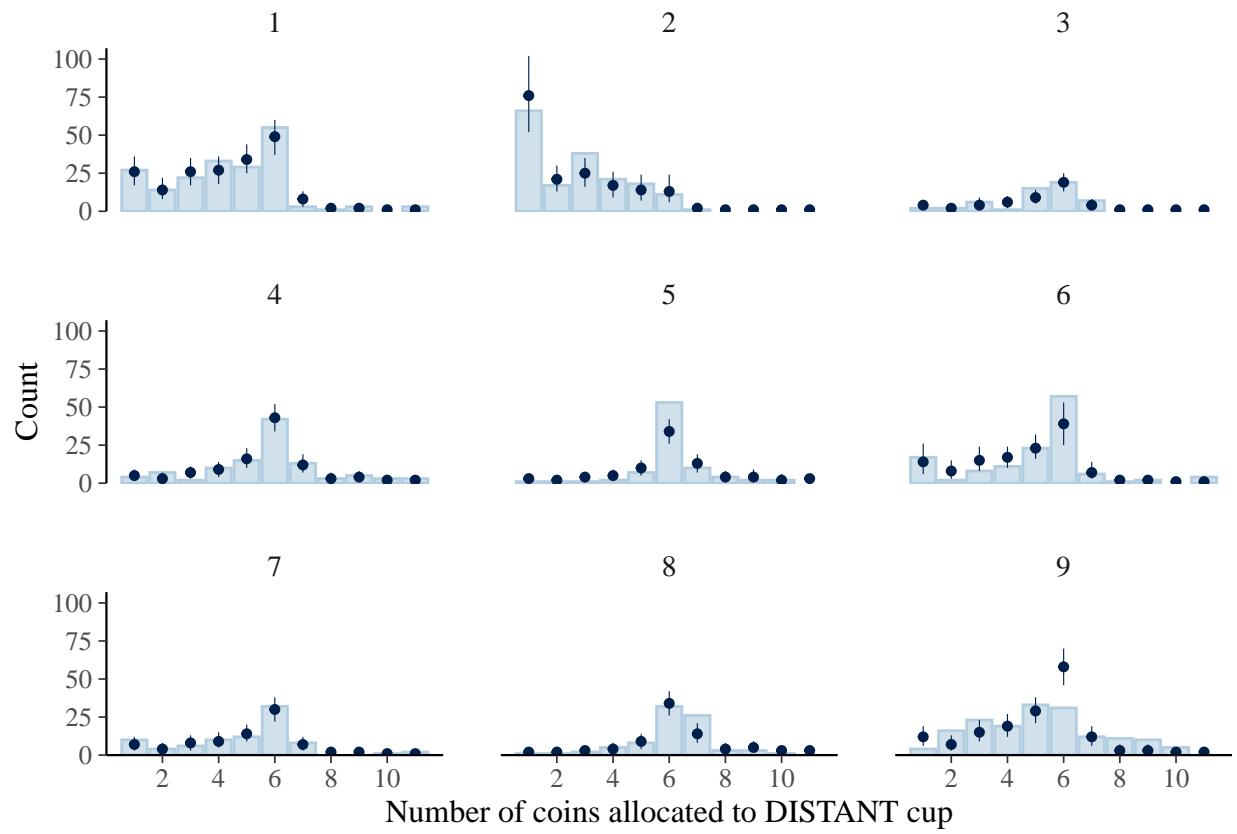


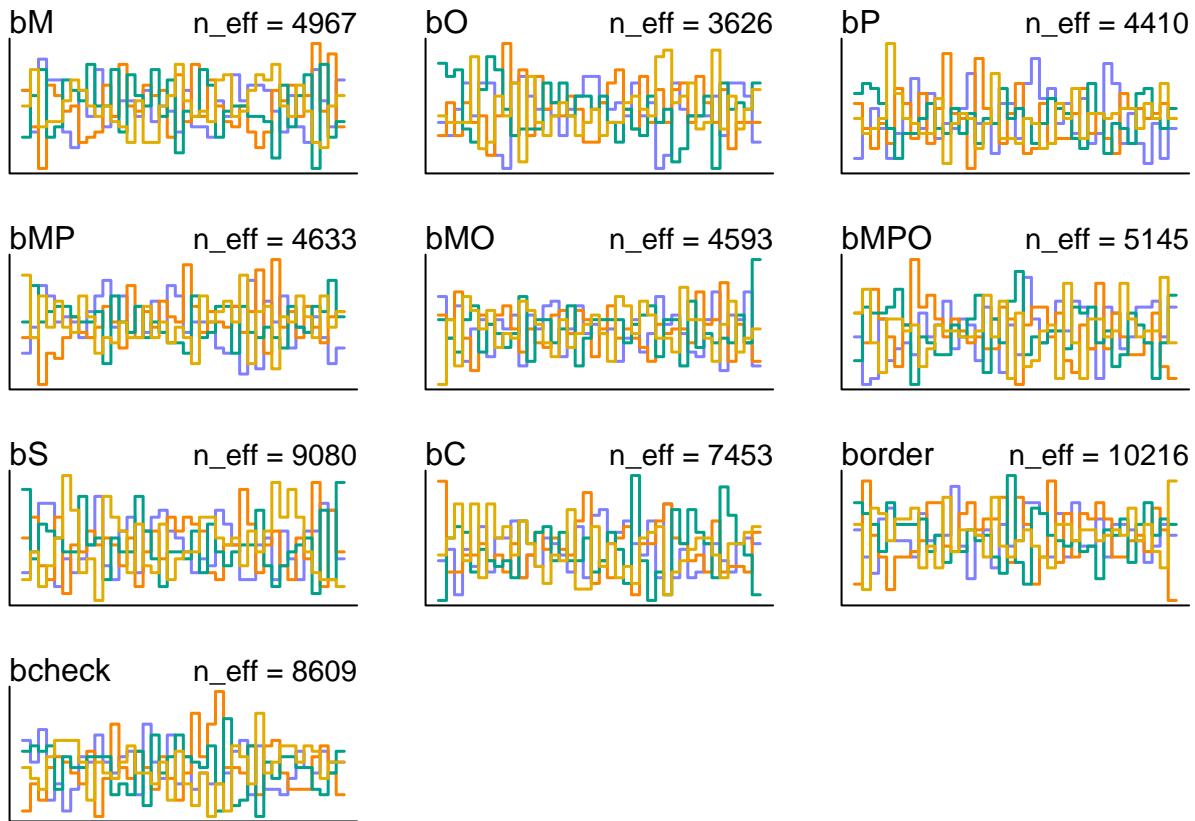
```
##           elpd_diff se_diff
## model2    0.0      0.0
## model1 -1.9      2.0
```

DG MV LOCAL INT

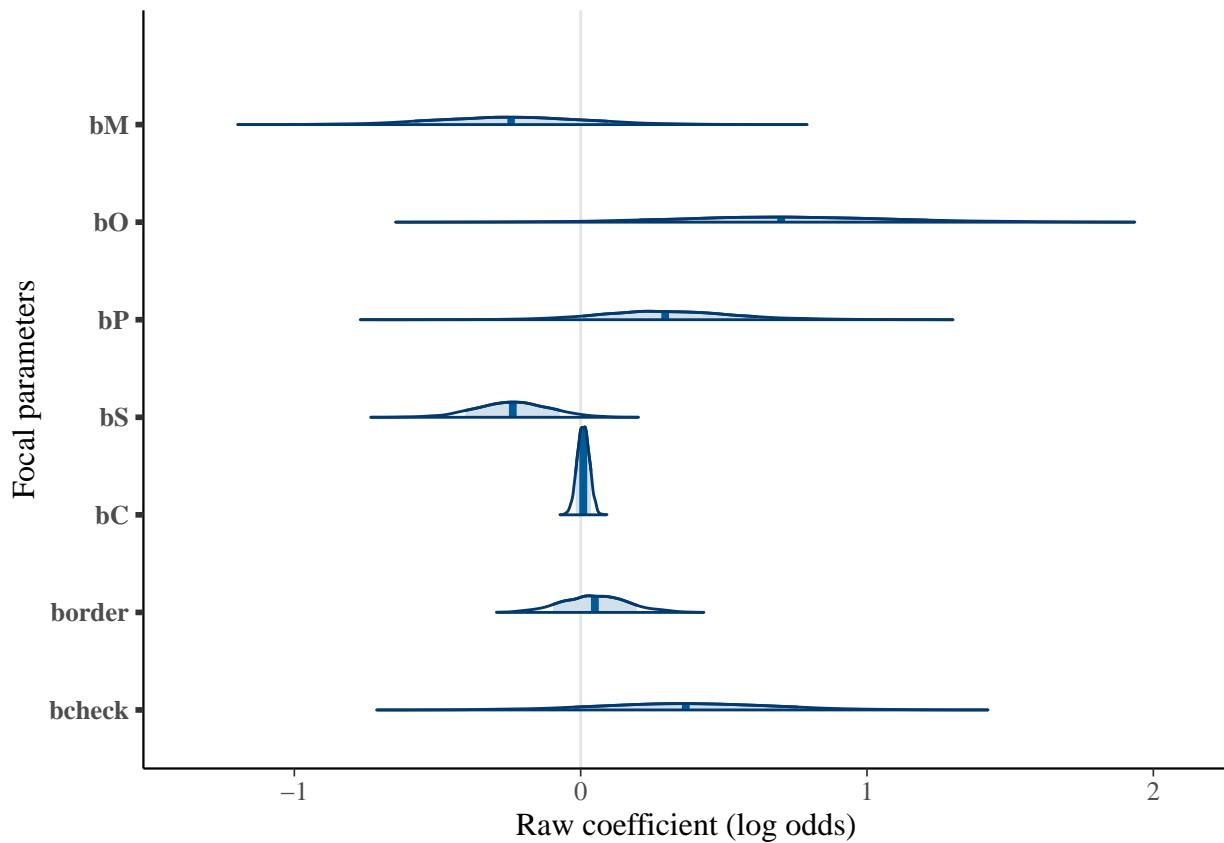
```
## Warning: 1 of 4000 (0.0%) transitions ended with a divergence.  
## See https://mc-stan.org/misc/warnings for details.
```

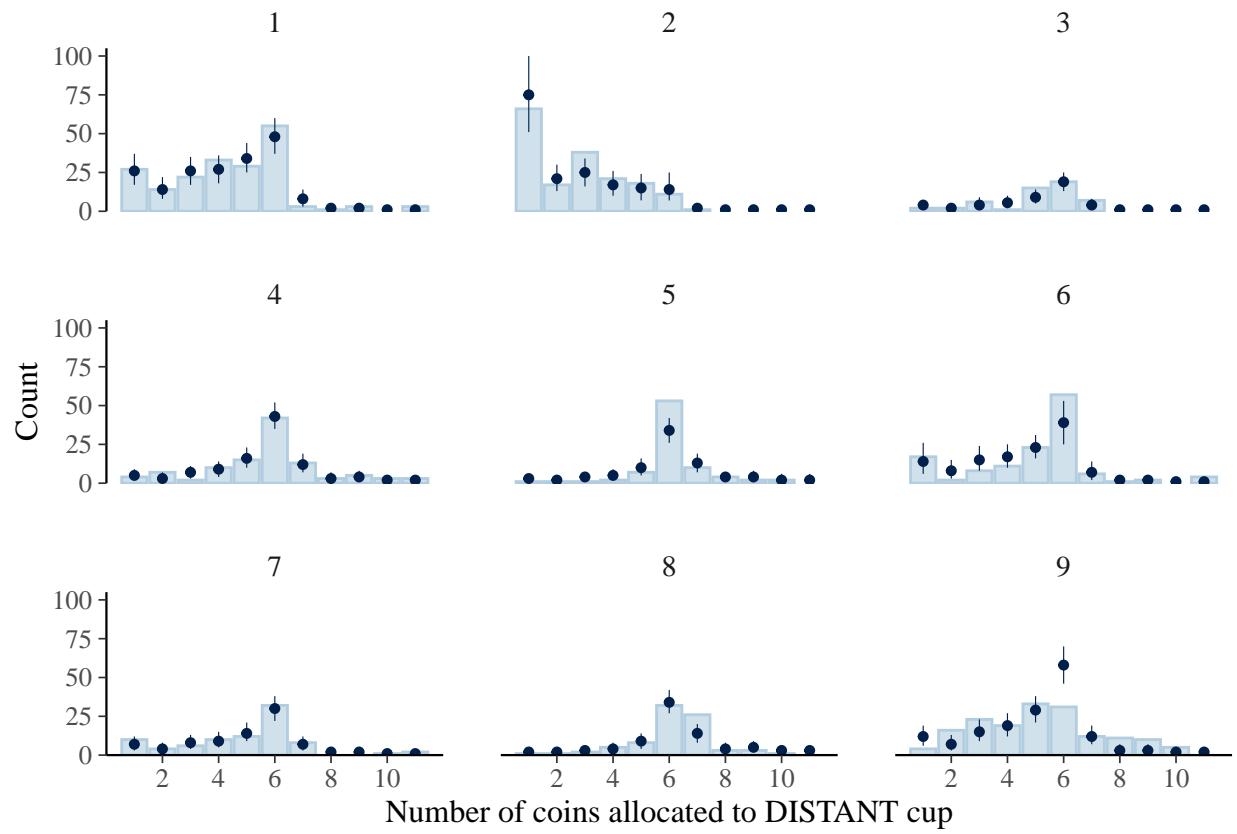


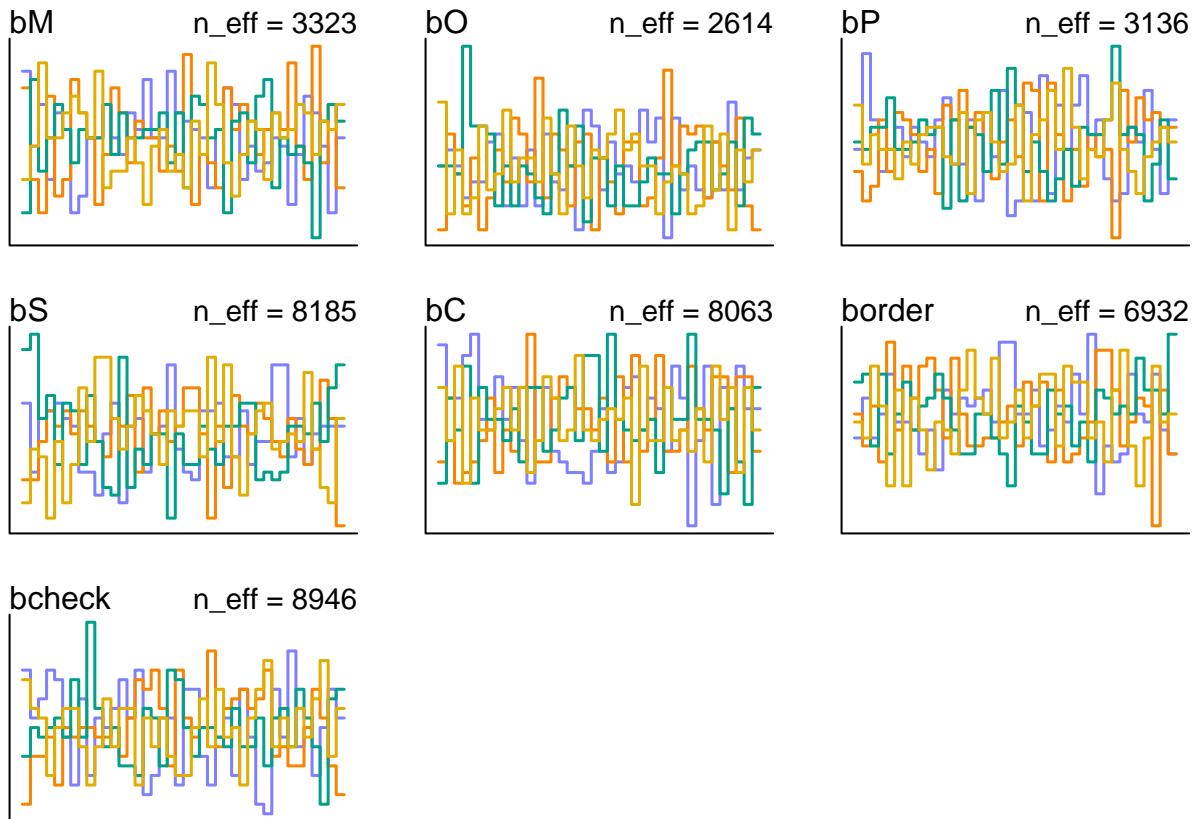




DG MV LOCAL ADD







```
##           elpd_diff se_diff
## model2    0.0      0.0
## model1 -2.7      2.0
```

References

We used R version 4.1.2 (R Core Team 2021) and the following R packages: abind v. 1.4.5 (Plate and Heiberger 2016), arrayhelpers v. 1.1.0 (Beleites 2020), backports v. 1.4.1 (Lang and R Core Team 2021), base64enc v. 0.1.3 (Urbanek 2015), bayesplot v. 1.8.1 (Gabry et al. 2019; Gabry and Mahr 2021), bdsmatrix v. 1.3.6 (Therneau 2022), BH v. 1.78.0.0 (Eddelbuettel, Emerson, and Kane 2021), brio v. 1.1.3 (Hester and Csárdi 2021), bslib v. 0.3.1 (Sievert and Cheng 2021a), cachem v. 1.0.6 (Chang 2021a), callr v. 3.7.0 (Csárdi and Chang 2021a), checkmate v. 2.0.0 (Lang 2017), coda v. 0.19.4 (Plummer et al. 2006), colorspace v. 2.0.3 (Zeileis, Hornik, and Murrell 2009; Stauffer et al. 2009; Zeileis et al. 2020), commonmark v. 1.7 (Ooms 2018), cpp11 v. 0.4.2 (Hester and François 2021), curl v. 4.3.2 (Ooms 2021), data.table v. 1.14.2 (Dowle and Srinivasan 2021), desc v. 1.4.0 (Csárdi, Müller, and Hester 2021), diffobj v. 0.3.5 (Gaslam 2021), digest v. 0.6.29 (Antoine Lucas et al. 2021), distributional v. 0.3.0 (O’Hara-Wild, Kay, and Hayes 2022), ellipsis v. 0.3.2 (H. Wickham 2021a), evaluate v. 0.15 (H. Wickham and Xie 2022), fansi v. 1.0.2 (Gaslam 2022), farver v. 2.1.0 (Pedersen, Nicolae, and François 2021), fastmap v. 1.1.0 (Chang 2021b), finalfit v. 1.0.6 (Harrison, Drake, and Ots 2023), fs v. 1.5.2 (Hester, Wickham, and Csárdi 2021), generics v. 0.1.2 (H. Wickham, Kuhn, and Vaughan 2022), GGally v. 2.1.2 (Schlöerke et al. 2021), ggdist v. 3.1.1 (Kay 2022a), ggridges v. 0.5.3 (Wilke 2021), ggtext v. 0.1.1 (Wilke 2020a), glue v. 1.6.1 (Hester and Bryan 2022), grateful v. 0.1.11 (Rodríguez-Sánchez, Jackson, and Hutchins 2022), gridExtra v. 2.3 (Auguie 2017), gridtext v. 0.1.4 (Wilke 2020b), gtable v. 0.3.0 (H. Wickham and Pedersen 2019), HDInterval v. 0.2.2 (Meredith and Kruschke 2020), highr v. 0.9 (Xie and Qiu 2021), htmltools v. 0.5.2 (Cheng et al. 2021), inline v. 0.3.19 (Sklyar et al. 2021), isoband v. 0.2.5 (Wilke and Pedersen 2021), jpeg v. 0.1.9 (Urbanek 2021), jquerylib v. 0.1.4 (Sievert and Cheng 2021b), knitr v. 1.39 (Xie 2014, 2015, 2022a), labeling v. 0.4.2 (Justin Talbot 2020), lifecycle v. 1.0.1 (Henry and Wickham 2021), lme4 v. 1.1.28 (Bates et al. 2015), loo v. 2.4.1 (Vehtari, Gelman, and Gabry 2017; Yao et al. 2017; Vehtari et al. 2020), markdown v. 1.1 (Allaire et al. 2019), matrixStats v. 0.61.0 (Bengtsson 2021), memoise v. 2.0.1 (H. Wickham, Hester, et al. 2021), mice v. 3.14.0 (van Buuren and Groothuis-Oudshoorn 2011), mime v. 0.12 (Xie 2021a), minqa v. 1.2.4 (Bates et al. 2014), munsell v. 0.5.0 (C. Wickham 2018), nloptr v. 2.0.0 (Johnson ?), numDeriv v. 2016.8.1.1 (Gilbert and Varadhan 2019), patchwork v. 1.1.1 (Pedersen 2020), pkgbuild v. 1.3.1 (H. Wickham, Hester, and Csárdi 2021), pkgconfig v. 2.0.3 (Csárdi 2019), pkgload v. 1.2.4 (H. Wickham, Chang, et al. 2021), plyr v. 1.8.6 (H. Wickham 2011b), png v. 0.1.7 (Urbanek 2013), posterior v. 1.2.0 (Vehtari et al. 2021; Bürkner et al. 2022), praise v. 1.0.0 (Csárdi and Sorhus 2015), prettyunits v. 1.1.1 (Csárdi 2020), pROC v. 1.18.0 (Robin et al. 2011), processx v. 3.5.2 (Csárdi and Chang 2021b), progress v. 1.2.2 (Csárdi and FitzJohn 2019), ps v. 1.6.0 (Loden et al. 2021), quadprog v. 1.5.8 (Berwin A. Turlach R port by Andreas Weingessel <Andreas.Weingessel@ci.tuwien.ac.at> Fortran contributions from Cleve Moler dpodi/LINPACK) 2019), R6 v. 2.5.1 (Chang 2021c), rappdirs v. 0.3.3 (Ratnakumar, Mick, and Davis 2021), RColorBrewer v. 1.1.2 (Neuwirth 2014), Rcpp v. 1.0.8 (Eddelbuettel and François 2011; Eddelbuettel 2013; Eddelbuettel and Balamuta 2018), RcppEigen v. 0.3.3.9.1 (Bates and Eddelbuettel 2013), RcppParallel v. 5.1.5 (Allaire, Francois, et al. 2022), rematch2 v. 2.1.2 (Csárdi 2020), renv v. 0.16.0 (Ushey 2022), reshape v. 0.8.9 (H. Wickham 2007a), reshape2 v. 1.4.4 (H. Wickham 2007b), rethinking v. 2.21 (McElreath 2021), rmarkdown v. 2.14 (Xie, Allaire, and Grolemund 2018; Xie, Dervieux, and Riederer 2020; Allaire, Xie, et al. 2022), rprojroot v. 2.0.2 (Müller 2020), rstan v. 2.21.3 (Stan Development Team 2021), sass v. 0.4.1 (Cheng et al. 2022), scales v. 1.1.1 (H. Wickham and Seidel 2020), StanHeaders v. 2.21.0.7 (Stan Development Team 2020), stringi v. 1.7.6 (Gagolewski 2021a, 2021b), svUnit v. 1.0.6 (Grosjean 2021), tensorA v. 0.36.2 (van den Boogaart 2020), testthat v. 3.1.2 (H. Wickham 2011a), tidybayes v. 3.0.2 (Kay 2022b), tidyselect v. 1.1.2 (Henry and Wickham 2022), tidyverse v. 1.3.2 (H. Wickham et al. 2019), tinytex v. 0.38 (Xie 2019, 2022b), utf8 v. 1.2.2 (Perry 2021), vctrs v. 0.3.8 (H. Wickham, Henry, and Vaughan 2021), viridisLite v. 0.4.0 (Garnier et al. 2021), waldo v. 0.3.1 (H. Wickham 2021b), withr v. 2.5.0 (Hester et al. 2022), xfun v. 0.29 (Xie 2021b), yaml v. 2.3.5 (Garbett et al. 2022). Allaire, JJ, Romain Francois, Kevin Ushey, Gregory Vandebrouck, Marcus Geelnard, and Intel. 2022. *RcppParallel: Parallel Programming Tools for ‘Rcpp’*. <https://CRAN.R-project.org/package=RcppParallel>.

Allaire, JJ, Jeffrey Horner, Yihui Xie, Vicent Martí, and Natacha Porte. 2019. *Markdown: Render Markdown with the c Library ‘Sundown’*. <https://CRAN.R-project.org/package=markdown>.

Allaire, JJ, Yihui Xie, Jonathan McPherson, Javier Luraschi, Kevin Ushey, Aron Atkins, Hadley Wickham, Joe Cheng, Winston Chang, and Richard Iannone. 2022. *Rmarkdown: Dynamic Documents for r*.

- <https://github.com/rstudio/rmarkdown>.
- Antoine Lucas, Dirk Eddelbuettel with contributions by, Jarek Tuszynski, Henrik Bengtsson, Simon Urbanek, Mario Frasca, Bryan Lewis, Murray Stokely, et al. 2021. *Digest: Create Compact Hash Digests of r Objects*. <https://CRAN.R-project.org/package=digest>.
- Auguie, Baptiste. 2017. *gridExtra: Miscellaneous Functions for "Grid" Graphics*. <https://CRAN.R-project.org/package=gridExtra>.
- Bates, Douglas, and Dirk Eddelbuettel. 2013. “Fast and Elegant Numerical Linear Algebra Using the RcppEigen Package.” *Journal of Statistical Software* 52 (5): 1–24. <https://www.jstatsoft.org/v52/i05/>.
- Bates, Douglas, Martin Mächler, Ben Bolker, and Steve Walker. 2015. “Fitting Linear Mixed-Effects Models Using lme4.” *Journal of Statistical Software* 67 (1): 1–48. <https://doi.org/10.18637/jss.v067.i01>.
- Bates, Douglas, Katharine M. Mullen, John C. Nash, and Ravi Varadhan. 2014. *Minqa: Derivative-Free Optimization Algorithms by Quadratic Approximation*. <https://CRAN.R-project.org/package=minqa>.
- Beleites, C. 2020. *Arrayhelpers: Convenience Functions for Arrays*. <https://CRAN.R-project.org/package=arrayhelpers>.
- Bengtsson, Henrik. 2021. *matrixStats: Functions That Apply to Rows and Columns of Matrices (and to Vectors)*. <https://CRAN.R-project.org/package=matrixStats>.
- Berwin A. Turlach R port by Andreas Weingessel <Andreas.Weingessel@ci.tuwien.ac.at> Fortran contributions from Cleve Moler dpodi/LINPACK), S original by. 2019. *Quadprog: Functions to Solve Quadratic Programming Problems*. <https://CRAN.R-project.org/package=quadprog>.
- Bürkner, Paul-Christian, Jonah Gabry, Matthew Kay, and Aki Vehtari. 2022. “Posterior: Tools for Working with Posterior Distributions.” <https://mc-stan.org/posterior/>.
- Chang, Winston. 2021a. *Cachem: Cache r Objects with Automatic Pruning*. <https://CRAN.R-project.org/package=cachem>.
- . 2021b. *Fastmap: Fast Data Structures*. <https://CRAN.R-project.org/package=fastmap>.
- . 2021c. *R6: Encapsulated Classes with Reference Semantics*. <https://CRAN.R-project.org/package=R6>.
- Cheng, Joe, Timothy Mastny, Richard Iannone, Barret Schloerke, and Carson Sievert. 2022. *Sass: Syntactically Awesome Style Sheets ('Sass')*. <https://CRAN.R-project.org/package=sass>.
- Cheng, Joe, Carson Sievert, Barret Schloerke, Winston Chang, Yihui Xie, and Jeff Allen. 2021. *Htmltools: Tools for HTML*. <https://CRAN.R-project.org/package=htmltools>.
- Csardi, Gabor. 2020. *Prettyunits: Pretty, Human Readable Formatting of Quantities*. <https://CRAN.R-project.org/package=prettyunits>.
- Csardi, Gabor, and Sindre Sorhus. 2015. *Praise: Praise Users*. <https://CRAN.R-project.org/package=praise>.
- Csárdi, Gábor. 2019. *Pkgconfig: Private Configuration for 'r' Packages*. <https://CRAN.R-project.org/package=pkgconfig>.
- . 2020. *Rematch2: Tidy Output from Regular Expression Matching*. <https://CRAN.R-project.org/package=rematch2>.
- Csárdi, Gábor, and Winston Chang. 2021a. *Callr: Call r from r*. <https://CRAN.R-project.org/package=callr>.
- . 2021b. *Processx: Execute and Control System Processes*. <https://CRAN.R-project.org/package=processx>.
- Csárdi, Gábor, and Rich FitzJohn. 2019. *Progress: Terminal Progress Bars*. <https://CRAN.R-project.org/package=progress>.
- Csárdi, Gábor, Kirill Müller, and Jim Hester. 2021. *Desc: Manipulate DESCRIPTION Files*. <https://CRAN.R-project.org/package=desc>.
- Dowle, Matt, and Arun Srinivasan. 2021. *Data.table: Extension of 'Data.frame'*. <https://CRAN.R-project.org/package=data.table>.
- Eddelbuettel, Dirk. 2013. *Seamless R and C++ Integration with Rcpp*. New York: Springer. <https://doi.org/10.1007/978-1-4614-6868-4>.
- Eddelbuettel, Dirk, and James Joseph Balamuta. 2018. “Extending extitR with extitC++: A Brief Introduction to extitRcpp.” *The American Statistician* 72 (1): 28–36. <https://doi.org/10.1080/00031305.2017.1375990>.
- Eddelbuettel, Dirk, John W. Emerson, and Michael J. Kane. 2021. *BH: Boost c++ Header Files*. <https://CRAN.R-project.org/package=BH>.
- Eddelbuettel, Dirk, and Romain François. 2011. “Rcpp: Seamless R and C++ Integration.” *Journal of*

- Statistical Software* 40 (8): 1–18. <https://doi.org/10.18637/jss.v040.i08>.
- Gabry, Jonah, and Tristan Mahr. 2021. “Bayesplot: Plotting for Bayesian Models.” <https://mc-stan.org/bayesplot/>.
- Gabry, Jonah, Daniel Simpson, Aki Vehtari, Michael Betancourt, and Andrew Gelman. 2019. “Visualization in Bayesian Workflow.” *J. R. Stat. Soc. A* 182: 389–402. <https://doi.org/10.1111/rssa.12378>.
- Gagolewski, Marek. 2021a. “Stringi: Fast and Portable Character String Processing in r.” *Journal of Statistical Software*.
- . 2021b. *Stringi: Fast and Portable Character String Processing in r*. <https://stringi.gagolewski.com/>.
- Garbett, Shawn P, Jeremy Stephens, Kirill Simonov, Yihui Xie, Zhuoer Dong, Hadley Wickham, Jeffrey Horner, et al. 2022. *Yaml: Methods to Convert r Data to YAML and Back*. <https://CRAN.R-project.org/package=yaml>.
- Garnier, Simon, Ross, Noam, Rudis, Robert, Camargo, et al. 2021. *viridis - Colorblind-Friendly Color Maps for r*. <https://doi.org/10.5281/zenodo.4679424>.
- Gaslam, Brodie. 2021. *Diffobj: Diffs for r Objects*. <https://CRAN.R-project.org/package=diffobj>.
- . 2022. *Fansi: ANSI Control Sequence Aware String Functions*. <https://CRAN.R-project.org/package=fansi>.
- Gilbert, Paul, and Ravi Varadhan. 2019. *numDeriv: Accurate Numerical Derivatives*. <https://CRAN.R-project.org/package=numDeriv>.
- Grosjean, Philippe. 2021. *SciViews-r*. MONS, Belgium: UMONS. <https://www.sciviews.org/SciViews-R/>.
- Harrison, Ewen, Tom Drake, and Riinu Ots. 2023. *Finalfit: Quickly Create Elegant Regression Results Tables and Plots When Modelling*. <https://CRAN.R-project.org/package=finalfit>.
- Henry, Lionel, and Hadley Wickham. 2021. *Lifecycle: Manage the Life Cycle of Your Package Functions*. <https://CRAN.R-project.org/package=lifecycle>.
- . 2022. *Tidyselect: Select from a Set of Strings*. <https://CRAN.R-project.org/package=tidyselect>.
- Hester, Jim, and Jennifer Bryan. 2022. *Glue: Interpreted String Literals*. <https://CRAN.R-project.org/package=glue>.
- Hester, Jim, and Gábor Csárdi. 2021. *Brio: Basic r Input Output*. <https://CRAN.R-project.org/package=brio>.
- Hester, Jim, and Romain François. 2021. *Cpp11: A c++11 Interface for r's c Interface*. <https://CRAN.R-project.org/package=cpp11>.
- Hester, Jim, Lionel Henry, Kirill Müller, Kevin Ushey, Hadley Wickham, and Winston Chang. 2022. *Withr: Run Code 'with' Temporarily Modified Global State*. <https://CRAN.R-project.org/package=withr>.
- Hester, Jim, Hadley Wickham, and Gábor Csárdi. 2021. *Fs: Cross-Platform File System Operations Based on 'Libuv'*. <https://CRAN.R-project.org/package=fs>.
- Johnson, Steven G. ? “The NLOpt Nonlinear-Optimization Package.” ? ? (?): ?
- Justin Talbot. 2020. *Labeling: Axis Labeling*. <https://CRAN.R-project.org/package=labeling>.
- Kay, Matthew. 2022a. *ggdist: Visualizations of Distributions and Uncertainty*. <https://doi.org/10.5281/zenodo.3879620>.
- . 2022b. *tidybayes: Tidy Data and Geoms for Bayesian Models*. <https://doi.org/10.5281/zenodo.1308151>.
- Lang, Michel. 2017. “checkmate: Fast Argument Checks for Defensive r Programming.” *The R Journal* 9 (1): 437–45. <https://journal.r-project.org/archive/2017/RJ-2017-028/index.html>.
- Lang, Michel, and R Core Team. 2021. *Backports: Reimplementations of Functions Introduced Since r-3.0.0*. <https://CRAN.R-project.org/package=backports>.
- Loden, Jay, Dave Daeschler, Giampaolo Rodola', and Gábor Csárdi. 2021. *Ps: List, Query, Manipulate System Processes*. <https://CRAN.R-project.org/package=ps>.
- McElreath, Richard. 2021. *Rethinking: Statistical Rethinking Book Package*.
- Meredith, Mike, and John Kruschke. 2020. *HDInterval: Highest (Posterior) Density Intervals*. <https://CRAN.R-project.org/package=HDInterval>.
- Müller, Kirill. 2020. *Rprojroot: Finding Files in Project Subdirectories*. <https://CRAN.R-project.org/package=rprojroot>.
- Neuwirth, Erich. 2014. *RColorBrewer: ColorBrewer Palettes*. <https://CRAN.R-project.org/package=RColorBrewer>.
- O'Hara-Wild, Mitchell, Matthew Kay, and Alex Hayes. 2022. *Distributional: Vectorised Probability Distributions*. <https://CRAN.R-project.org/package=distributional>.

- Ooms, Jeroen. 2018. *Commonmark: High Performance CommonMark and Github Markdown Rendering in r*. <https://CRAN.R-project.org/package=commonmark>.
- . 2021. *Curl: A Modern and Flexible Web Client for r*. <https://CRAN.R-project.org/package=curl>.
- Pedersen, Thomas Lin. 2020. *Patchwork: The Composer of Plots*. <https://CRAN.R-project.org/package=patchwork>.
- Pedersen, Thomas Lin, Berendea Nicolae, and Romain François. 2021. *Farver: High Performance Colour Space Manipulation*. <https://CRAN.R-project.org/package=farver>.
- Perry, Patrick O. 2021. *Utf8: Unicode Text Processing*. <https://CRAN.R-project.org/package=utf8>.
- Plate, Tony, and Richard Heiberger. 2016. *Abind: Combine Multidimensional Arrays*. <https://CRAN.R-project.org/package=abind>.
- Plummer, Martyn, Nicky Best, Kate Cowles, and Karen Vines. 2006. “CODA: Convergence Diagnosis and Output Analysis for MCMC.” *R News* 6 (1): 7–11. <https://journal.r-project.org/archive/>.
- R Core Team. 2021. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing. <https://www.R-project.org/>.
- Ratnakumar, Sridhar, Trent Mick, and Trevor Davis. 2021. *Rappdirs: Application Directories: Determine Where to Save Data, Caches, and Logs*. <https://CRAN.R-project.org/package=rappdirs>.
- Robin, Xavier, Natacha Turck, Alexandre Hainard, Natalia Tiberti, Frédérique Lisacek, Jean-Charles Sanchez, and Markus Müller. 2011. “pROC: An Open-Source Package for r and s+ to Analyze and Compare ROC Curves.” *BMC Bioinformatics* 12: 77.
- Rodríguez-Sánchez, Francisco, Connor P. Jackson, and Shaurita D. Hutchins. 2022. *Grateful: Facilitate Citation of r Packages*. <https://github.com/Pakillo/grateful>.
- Schloerke, Barret, Di Cook, Joseph Larmarange, Francois Briatte, Moritz Marbach, Edwin Thoen, Amos Elberg, and Jason Crowley. 2021. *GGally: Extension to 'Ggplot2'*. <https://CRAN.R-project.org/package=GGally>.
- Sievert, Carson, and Joe Cheng. 2021a. *Bslib: Custom 'Bootstrap' 'Sass' Themes for 'Shiny' and 'Rmarkdown'*. <https://CRAN.R-project.org/package=bslib>.
- . 2021b. *Jquerylib: Obtain 'jQuery' as an HTML Dependency Object*. <https://CRAN.R-project.org/package=jquerylib>.
- Sklar, Oleg, Duncan Murdoch, Mike Smith, Dirk Eddelbuettel, Romain Francois, Karline Soetaert, and Johannes Ranke. 2021. *Inline: Functions to Inline c, c++, Fortran Function Calls from r*. <https://CRAN.R-project.org/package=inline>.
- Stan Development Team. 2020. “StanHeaders: Headers for the R Interface to Stan.” <https://mc-stan.org/>.
- . 2021. “RStan: The R Interface to Stan.” <https://mc-stan.org/>.
- Stauffer, Reto, Georg J. Mayr, Markus Dabernig, and Achim Zeileis. 2009. “Somewhere over the Rainbow: How to Make Effective Use of Colors in Meteorological Visualizations.” *Bulletin of the American Meteorological Society* 96 (2): 203–16. <https://doi.org/10.1175/BAMS-D-13-00155.1>.
- Therneau, Terry. 2022. *Bdsmatrix: Routines for Block Diagonal Symmetric Matrices*. <https://CRAN.R-project.org/package=bdsmatrix>.
- Urbanek, Simon. 2013. *Png: Read and Write PNG Images*. <https://CRAN.R-project.org/package=png>.
- . 2015. *Base64enc: Tools for Base64 Encoding*. <https://CRAN.R-project.org/package=base64enc>.
- . 2021. *Jpeg: Read and Write JPEG Images*. <https://CRAN.R-project.org/package=jpeg>.
- Ushey, Kevin. 2022. *Renv: Project Environments*. <https://CRAN.R-project.org/package=renv>.
- van Buuren, Stef, and Karin Groothuis-Oudshoorn. 2011. “mice: Multivariate Imputation by Chained Equations in r.” *Journal of Statistical Software* 45 (3): 1–67. <https://doi.org/10.18637/jss.v045.i03>.
- van den Boogaart, K. Gerald. 2020. *tensorA: Advanced Tensor Arithmetic with Named Indices*. <https://CRAN.R-project.org/package=tensorA>.
- Vehtari, Aki, Jonah Gabry, Mans Magnusson, Yuling Yao, Paul-Christian Bürkner, Topi Paananen, and Andrew Gelman. 2020. “Loo: Efficient Leave-One-Out Cross-Validation and WAIC for Bayesian Models.” <https://mc-stan.org/loo/>.
- Vehtari, Aki, Andrew Gelman, and Jonah Gabry. 2017. “Practical Bayesian Model Evaluation Using Leave-One-Out Cross-Validation and WAIC.” *Statistics and Computing* 27: 1413–32. <https://doi.org/10.1007/s11222-016-9696-4>.
- Vehtari, Aki, Andrew Gelman, Daniel Simpson, Bob Carpenter, and Paul-Christian Bürkner. 2021. “Rank-Normalization, Folding, and Localization: An Improved Rhat for Assessing Convergence of MCMC (with

- Discussion)." *Bayesian Analysis*.
- Wickham, Charlotte. 2018. *Munsell: Utilities for Using Munsell Colours*. <https://CRAN.R-project.org/package=munsell>.
- Wickham, Hadley. 2007a. "Reshaping Data with the Reshape Package." *Journal of Statistical Software* 21 (12). <https://www.jstatsoft.org/v21/i12/>.
- . 2007b. "Reshaping Data with the reshape Package." *Journal of Statistical Software* 21 (12): 1–20. <http://www.jstatsoft.org/v21/i12/>.
- . 2011a. "Testthat: Get Started with Testing." *The R Journal* 3: 5–10. https://journal.r-project.org/archive/2011-1/RJournal_2011-1_Wickham.pdf.
- . 2011b. "The Split-Apply-Combine Strategy for Data Analysis." *Journal of Statistical Software* 40 (1): 1–29. <http://www.jstatsoft.org/v40/i01/>.
- . 2021a. *Ellipsis: Tools for Working with ...* <https://CRAN.R-project.org/package=ellipsis>.
- . 2021b. *Waldo: Find Differences Between r Objects*. <https://CRAN.R-project.org/package=waldo>.
- Wickham, Hadley, Mara Averick, Jennifer Bryan, Winston Chang, Lucy D'Agostino McGowan, Romain François, Garrett Grolemund, et al. 2019. "Welcome to the tidyverse." *Journal of Open Source Software* 4 (43): 1686. <https://doi.org/10.21105/joss.01686>.
- Wickham, Hadley, Winston Chang, Jim Hester, and Lionel Henry. 2021. *Pkgload: Simulate Package Installation and Attach*. <https://CRAN.R-project.org/package=pkgload>.
- Wickham, Hadley, Lionel Henry, and Davis Vaughan. 2021. *Vctrs: Vector Helpers*. <https://CRAN.R-project.org/package=vctrs>.
- Wickham, Hadley, Jim Hester, Winston Chang, Kirill Müller, and Daniel Cook. 2021. *Memoise: 'Memoisation' of Functions*. <https://CRAN.R-project.org/package=memoise>.
- Wickham, Hadley, Jim Hester, and Gábor Csárdi. 2021. *Pkgbuild: Find Tools Needed to Build r Packages*. <https://CRAN.R-project.org/package=pkgbuild>.
- Wickham, Hadley, Max Kuhn, and Davis Vaughan. 2022. *Generics: Common S3 Generics Not Provided by Base r Methods Related to Model Fitting*. <https://CRAN.R-project.org/package=generics>.
- Wickham, Hadley, and Thomas Lin Pedersen. 2019. *Gtable: Arrange 'Grobs' in Tables*. <https://CRAN.R-project.org/package=gtable>.
- Wickham, Hadley, and Dana Seidel. 2020. *Scales: Scale Functions for Visualization*. <https://CRAN.R-project.org/package=scales>.
- Wickham, Hadley, and Yihui Xie. 2022. *Evaluate: Parsing and Evaluation Tools That Provide More Details Than the Default*. <https://CRAN.R-project.org/package=evaluate>.
- Wilke, Claus O. 2020a. *Ggtext: Improved Text Rendering Support for 'Ggplot2'*. <https://CRAN.R-project.org/package=ggtext>.
- . 2020b. *Gridtext: Improved Text Rendering Support for 'Grid' Graphics*. <https://CRAN.R-project.org/package=gridtext>.
- . 2021. *Ggridges: Ridgeline Plots in 'Ggplot2'*. <https://CRAN.R-project.org/package=ggridges>.
- Wilke, Claus O., and Thomas Lin Pedersen. 2021. *Isoband: Generate Isolines and Isobands from Regularly Spaced Elevation Grids*. <https://CRAN.R-project.org/package=isoband>.
- Xie, Yihui. 2014. "Knitr: A Comprehensive Tool for Reproducible Research in R." In *Implementing Reproducible Computational Research*, edited by Victoria Stodden, Friedrich Leisch, and Roger D. Peng. Chapman; Hall/CRC. <http://www.crcpress.com/product/isbn/9781466561595>.
- . 2015. *Dynamic Documents with R and Knitr*. 2nd ed. Boca Raton, Florida: Chapman; Hall/CRC. <https://yihui.org/knitr/>.
- . 2019. "TinyTeX: A Lightweight, Cross-Platform, and Easy-to-Maintain LaTeX Distribution Based on TeX Live." *TUGboat*, no. 1: 30–32. <https://tug.org/TUGboat/Contents/contents40-1.html>.
- . 2021a. *Mime: Map Filenames to MIME Types*. <https://CRAN.R-project.org/package=mime>.
- . 2021b. *Xfun: Supporting Functions for Packages Maintained by 'Yihui Xie'*. <https://CRAN.R-project.org/package=xfun>.
- . 2022a. *Knitr: A General-Purpose Package for Dynamic Report Generation in r*. <https://yihui.org/knitr/>.
- . 2022b. *Tinytex: Helper Functions to Install and Maintain TeX Live, and Compile LaTeX Documents*. <https://github.com/yihui/tinytex>.
- Xie, Yihui, J. J. Allaire, and Garrett Grolemund. 2018. *R Markdown: The Definitive Guide*. Boca Raton,

- Florida: Chapman; Hall/CRC. <https://bookdown.org/yihui/rmarkdown>.
- Xie, Yihui, Christophe Dervieux, and Emily Riederer. 2020. *R Markdown Cookbook*. Boca Raton, Florida: Chapman; Hall/CRC. <https://bookdown.org/yihui/rmarkdown-cookbook>.
- Xie, Yihui, and Yixuan Qiu. 2021. *Highr: Syntax Highlighting for r Source Code*. <https://CRAN.R-project.org/package=highr>.
- Yao, Yuling, Aki Vehtari, Daniel Simpson, and Andrew Gelman. 2017. “Using Stacking to Average Bayesian Predictive Distributions.” *Bayesian Analysis*. <https://doi.org/10.1214/17-BA1091>.
- Zeileis, Achim, Jason C. Fisher, Kurt Hornik, Ross Ihaka, Claire D. McWhite, Paul Murrell, Reto Stauffer, and Claus O. Wilke. 2020. “colorspace: A Toolbox for Manipulating and Assessing Colors and Palettes.” *Journal of Statistical Software* 96 (1): 1–49. <https://doi.org/10.18637/jss.v096.i01>.
- Zeileis, Achim, Kurt Hornik, and Paul Murrell. 2009. “Escaping RGBland: Selecting Colors for Statistical Graphics.” *Computational Statistics & Data Analysis* 53 (9): 3259–70. <https://doi.org/10.1016/j.csda.2008.11.033>.