```
############### 0 - safe choice A, 1 - risky choice B ####################
library(rstan); rstan_options(javascript=FALSE)
```

```
## Loading required package: StanHeaders
```

```
## Loading required package: ggplot2
```

```
## rstan (Version 2.21.8, GitRev: 2e1f913d3ca3)
```

```
## For execution on a local, multicore CPU with excess RAM we recommend calling
## options(mc.cores = parallel::detectCores()).
## To avoid recompilation of unchanged Stan programs, we recommend calling
## rstan_options(auto_write = TRUE)
```

```
options(mc.cores = parallel::detectCores())
rstan_options(auto_write = T)

# Get list of files in 'data_2' folder with the pattern "riskytimed"
files <- dir(path = "data_2", pattern="riskytimed")

# Read all csv files in the list
data_list <- lapply(paste0("data_2/", files), read.table, header = TRUE, skip = 0,
fill = TRUE, sep= ";")

# Concatenate rows of all items in the list into a data frame
dat <- do.call("rbind", data_list)
```

```
# transform to +/- 1; safe - 1, risky +1
dat$cho <- ifelse(dat$choice==0,-1,ifelse(dat$choice==1,1,NA))
dat$cho2 <- ifelse(dat$choice==0,1,ifelse(dat$choice==1,0,NA))
ids <- unique(dat$id)
for(j in 1:length(ids)){
  dat$tid[dat$id==ids[j]] <- j
}
tids <- unique(dat$tid)
# only control data
control_dat <- dat[dat$cond=="control",]
# remove fast RTs
rcontrol_dat <- control_dat[control_dat$rt>1,]
# only condition no time pressure
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
rcontrol_dat <- rcontrol_dat %>%
  rowwise() %>%
  mutate(
    oa_condition = sum(c_across(starts_with("oa")) == 0),
    ob_condition = sum(c_across(starts_with("ob")) == 0)
  ) %>%
  filter(
    (oa_condition == 2 & ob_condition == 0) |
    (oa_condition == 0 & ob_condition == 2)
  )


library(dplyr)
library(stringr)


df <- rcontrol_dat %>%
  # Swap values if oa_condition is not 0
  rowwise() %>%
  mutate(
    temp_oa1 = if_else(oa_condition != 0, ob1, oa1),
    temp_oa2 = if_else(oa_condition != 0, ob2, oa2),
    temp_oa3 = if_else(oa_condition != 0, ob3, oa3),
    temp_oa4 = if_else(oa_condition != 0, ob4, oa4),
    temp_pa1 = if_else(oa_condition != 0, pb1, pa1),
    temp_pa2 = if_else(oa_condition != 0, pb2, pa2),
    temp_pa3 = if_else(oa_condition != 0, pb3, pa3),
    temp_pa4 = if_else(oa_condition != 0, pb4, pa4),
    temp_ob1 = if_else(oa_condition != 0, oa1, ob1),
    temp_ob2 = if_else(oa_condition != 0, oa2, ob2),
    temp_ob3 = if_else(oa_condition != 0, oa3, ob3),
    temp_ob4 = if_else(oa_condition != 0, oa4, ob4),
    temp_pb1 = if_else(oa_condition != 0, pa1, pb1),
    temp_pb2 = if_else(oa_condition != 0, pa2, pb2),
    temp_pb3 = if_else(oa_condition != 0, pa3, pb3),
    temp_pb4 = if_else(oa_condition != 0, pa4, pb4)
  ) %>%
  ungroup() %>%
  # Rename columns
  #select(-starts_with("oa"), -starts_with("ob"), -starts_with("pa"), -starts_with
```

```
("pb")) %>%
  rename_with(~ str_replace(., "temp_oa", "oc"), starts_with("temp_oa")) %>%
  rename_with(~ str_replace(., "temp_pa", "pc"), starts_with("temp_pa")) %>%
  rename_with(~ str_replace(., "temp_ob", "os"), starts_with("temp_ob")) %>%
  rename_with(~ str_replace(., "temp_pb", "ps"), starts_with("temp_pb"))



for(i in 1:nrow(df)) {
  if(df$oa_condition[i] == 0) {
    df$cho[i] <- -df$cho[i]
  } else if(df$oa_condition[i] == 2) {
  }
}
```

```
dataList  = list(cho = df$cho, rt = rcontrol_dat$rt, participant = rcontrol_dat$ti
d,N=nrow(rcontrol_dat),  L = length(tids),
                 oc = as.matrix(df[, c("oc1", "oc2", "oc3", "oc4")]),
                 os = as.matrix(df[, c("os1", "os2")]),
                 pc = as.matrix(df[, c("pc1", "pc2", "pc3", "pc4")]),
                 ps = as.matrix(df[, c("ps1", "ps2")]),
                 starting_point = 0.5
                 )

parameters = c("transf_mu_alpha","transf_mu_threshold","transf_mu_ndt", "transf_mu
_theta",'transf_mu_delta', 'transf_mu_gamma', 'sd_threshold',"sd_alpha","sd_ndt",
'sd_theta', 'sd_gamma','sd_delta', "alpha_sbj","threshold_sbj","ndt_sbj",'theta_sb
j', 'gamma_sbj', 'delta_sbj', "log_lik")
```

```
initFunc <-function (i) {
  initList=list()
  for (ll in 1:i){
    initList[[ll]] = list(
                          mu_alpha = runif(1,-1.4587,2.5413),
                          sd_alpha = runif(1,0,1),
                          mu_threshold = runif(1,-0.5, 2.5),
                          sd_threshold = runif(1,0,1),
                          mu_ndt = runif(1, -1.5, 0),
                          sd_ndt = runif(1, 0, 1),
                          mu_theta = runif(1,0, 6),
                          sd_theta = runif(1,0,1),
                          mu_gamma = runif(1,-1, 1),
                          sd_gamma = runif(1, 0, 1),
                          mu_delta = runif(1,-1, 1),
                          sd_delta = runif(1, 0, 1),
                          z_alpha = runif(length(tids),-0.1,0.1),
                          z_theta = runif(length(tids),-0.1,0.1),
                          z_threshold = runif(length(tids),-0.1,0.1),
                          z_ndt = runif(length(tids),-0.1,0.1),
                          z_gamma = runif(length(tids),-0.1,0.1),
                          z_delta = runif(length(tids),-0.1,0.1)
    )
  }

  return(initList)
}
```

```
m <- stan_model("EU_prob.stan")
```

```
## recompiling to avoid crashing R session
```

```
## Trying to compile a simple C file
```

```
## Running /usr/lib/R/bin/R CMD SHLIB foo.c
## using C compiler: ‘gcc (Ubuntu 11.4.0-1ubuntu1~22.04) 11.4.0’
## gcc -I"/usr/share/R/include" -DNDEBUG   -I"/usr/local/lib/R/site-library/Rcpp/i
nclude/"  -I"/usr/local/lib/R/site-library/RcppEigen/include/"  -I"/usr/local/lib/
R/site-library/RcppEigen/include/unsupported"  -I"/usr/local/lib/R/site-library/B
H/include" -I"/usr/local/lib/R/site-library/StanHeaders/include/src/"  -I"/usr/loc
al/lib/R/site-library/StanHeaders/include/"  -I"/usr/local/lib/R/site-library/Rcpp
Parallel/include/"  -I"/usr/local/lib/R/site-library/rstan/include" -DEIGEN_NO_DEB
UG  -DBOOST_DISABLE_ASSERTS  -DBOOST_PENDING_INTEGER_LOG2_HPP  -DSTAN_THREADS  -DB
OOST_NO_AUTO_PTR  -include '/usr/local/lib/R/site-library/StanHeaders/include/sta
n/math/prim/mat/fun/Eigen.hpp'  -D_REENTRANT -DRCPP_PARALLEL_USE_TBB=1       -fpic
-g -O2 -ffile-prefix-map=/build/r-base-MHXHhT/r-base-4.3.1=. -fstack-protector-str
ong -Wformat -Werror=format-security -Wdate-time -D_FORTIFY_SOURCE=2  -c foo.c -o
foo.o
## In file included from /usr/local/lib/R/site-library/RcppEigen/include/Eigen/Cor
e:88,
##                  from /usr/local/lib/R/site-library/RcppEigen/include/Eigen/Den
se:1,
##                  from /usr/local/lib/R/site-library/StanHeaders/include/stan/ma
th/prim/mat/fun/Eigen.hpp:13,
##                  from <command-line>:
## /usr/local/lib/R/site-library/RcppEigen/include/Eigen/src/Core/util/Macros.h:62
8:1: error: unknown type name ‘namespace’
##   628 | namespace Eigen {
##       | ^~~~~~~~~
## /usr/local/lib/R/site-library/RcppEigen/include/Eigen/src/Core/util/Macros.h:62
8:17: error: expected ‘=’, ‘,’, ‘;’, ‘asm’ or ‘__attribute__’ before ‘{’ token
##   628 | namespace Eigen {
##       |                 ^
## In file included from /usr/local/lib/R/site-library/RcppEigen/include/Eigen/Den
se:1,
##                  from /usr/local/lib/R/site-library/StanHeaders/include/stan/ma
th/prim/mat/fun/Eigen.hpp:13,
##                  from <command-line>:
## /usr/local/lib/R/site-library/RcppEigen/include/Eigen/Core:96:10: fatal error:
complex: No such file or directory
##    96 | #include <complex>
##       |          ^~~~~~~~~
## compilation terminated.
## make: *** [/usr/lib/R/etc/Makeconf:191: foo.o] Error 1
```

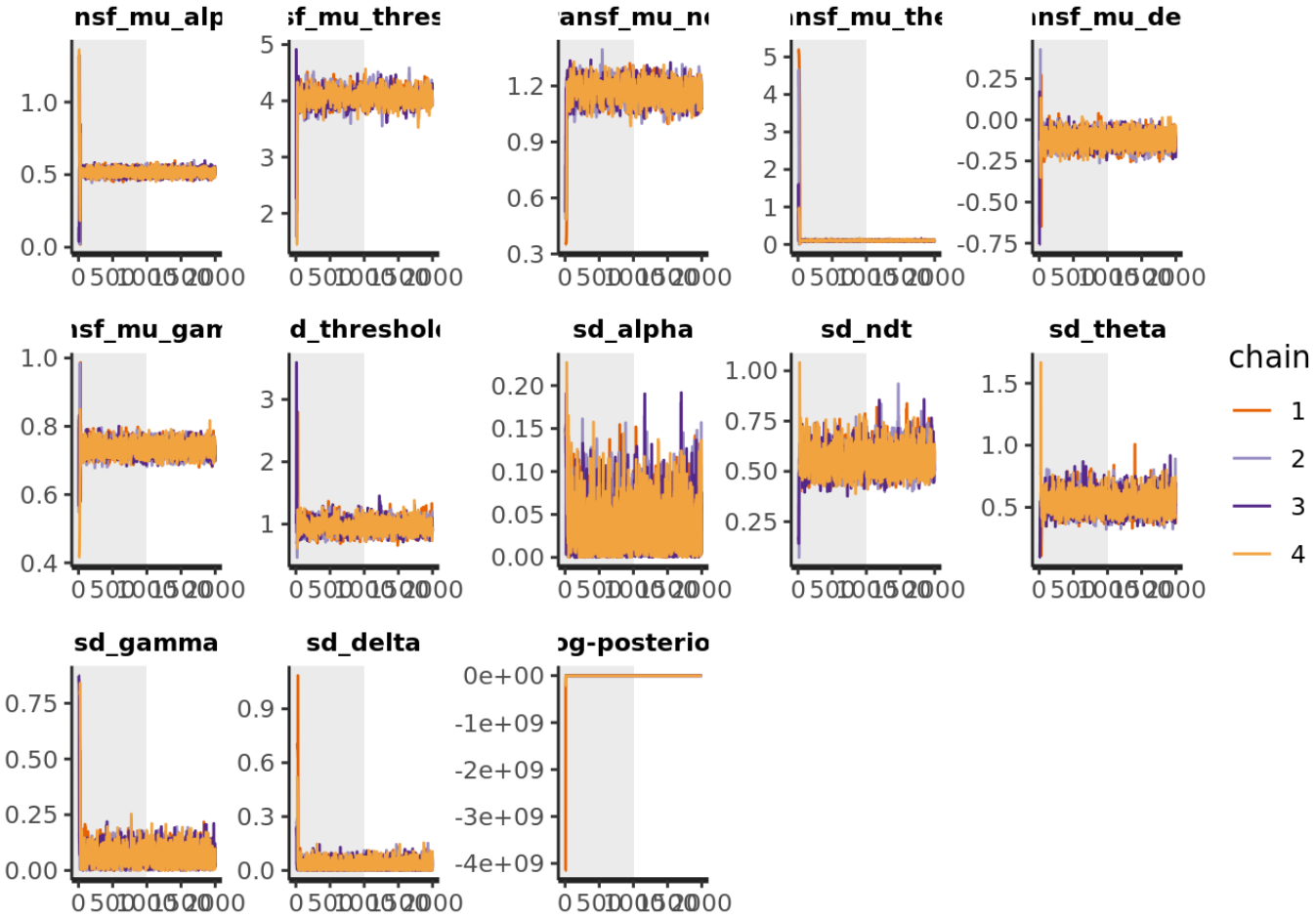
```
dsamples <- sampling(m,
                data=dataList,
                pars=parameters,
                iter=2000,
                chains=4,#If not specified, gives random inits
                init = initFunc(4),
                warmup = 1000,  # Stands for burn-in; Default = iter/2
                seed = 12,  # Setting seed; Default is random seed
                refresh = 0
                )
```

```
## Warning: There were 1 divergent transitions after warmup. See
## https://mc-stan.org/misc/warnings.html#divergent-transitions-after-warmup
## to find out why this is a problem and how to eliminate them.
```

```
## Warning: Examine the pairs() plot to diagnose sampling problems
```

```
## Warning: Bulk Effective Samples Size (ESS) is too low, indicating posterior mea
ns and medians may be unreliable.
## Running the chains for more iterations may help. See
## https://mc-stan.org/misc/warnings.html#bulk-ess
```

```
#"transf_mu_alpha","transf_mu_threshold","transf_mu_ndt", "transf_mu_theta",'trans
f_mu_delta', 'transf_mu_gamma', 'sd_threshold',"sd_alpha","sd_ndt", 'sd_theta', 's
d_gamma','sd_delta', "alpha_sbj","threshold_sbj","ndt_sbj",'theta_sbj', 'gamma_sb
j', 'delta_sbj',
rstan::traceplot(dsamples, pars=c("transf_mu_alpha","transf_mu_threshold","transf_
mu_ndt", "transf_mu_theta",'transf_mu_delta', 'transf_mu_gamma', 'sd_threshold',"s
d_alpha","sd_ndt", 'sd_theta', 'sd_gamma','sd_delta', "lp__"), inc_warmup = TRUE,
nrow = 3)
```




```
pairs(dsamples, pars = c("transf_mu_alpha","transf_mu_threshold","transf_mu_ndt",
"transf_mu_theta",'transf_mu_delta', 'transf_mu_gamma', 'sd_threshold',"sd_alph
a","sd_ndt", 'sd_theta', 'sd_gamma','sd_delta', "lp__"))
```

```
## Warning in par(usr): argument 1 does not name a graphical parameter

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```

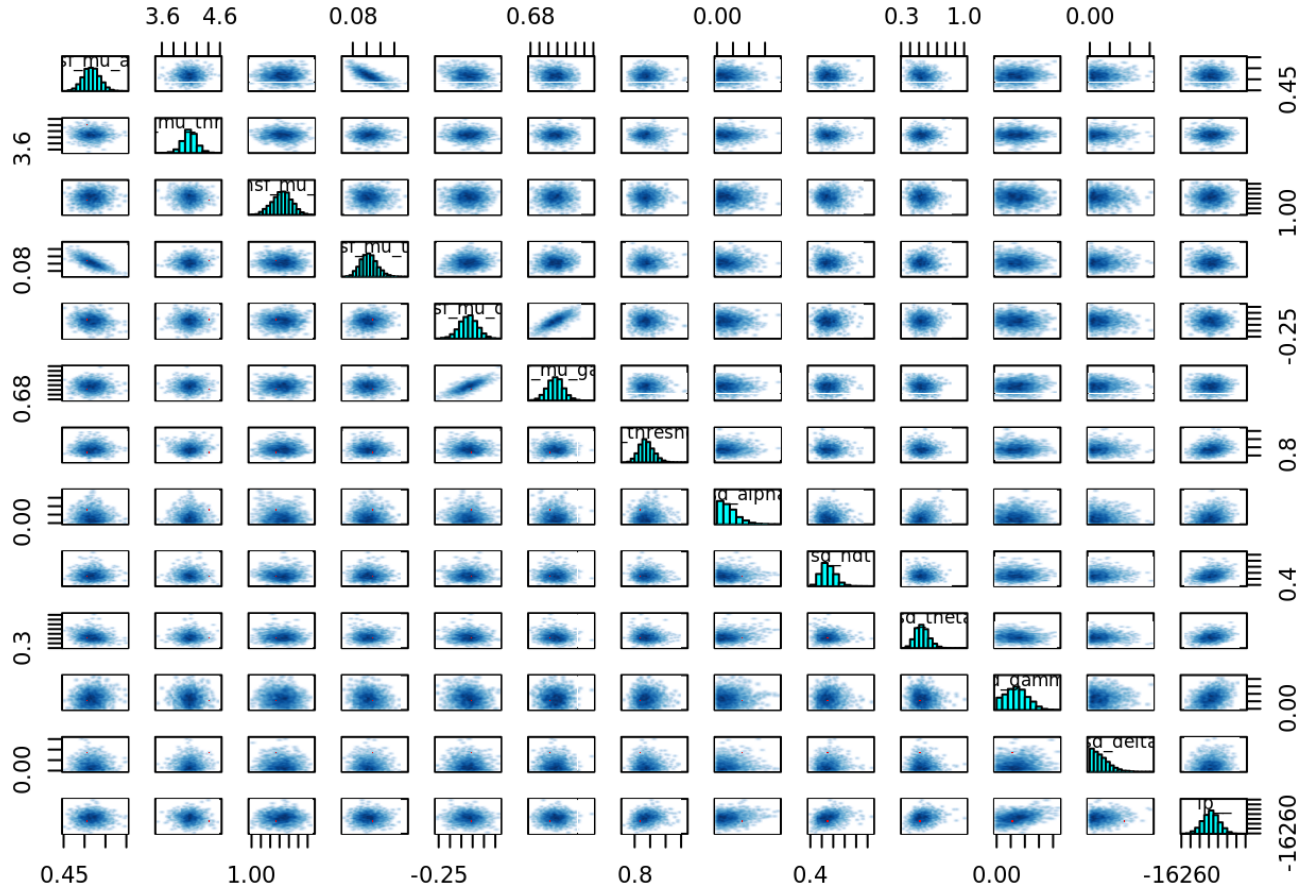


```
print(dsamples, pars = c("transf_mu_alpha","transf_mu_threshold","transf_mu_ndt",
"transf_mu_theta",'transf_mu_delta', 'transf_mu_gamma', 'sd_threshold',"sd_alph
a","sd_ndt", 'sd_theta', 'sd_gamma','sd_delta', "lp__"))
```

```
## Inference for Stan model: EU_prob.
## 4 chains, each with iter=2000; warmup=1000; thin=1;
## post-warmup draws per chain=1000, total post-warmup draws=4000.
##
##                          mean se_mean    sd      2.5%       25%       50%
## transf_mu_alpha          0.52    0.00  0.02      0.48      0.50      0.52
## transf_mu_threshold      4.08    0.01  0.12      3.83      4.00      4.08
## transf_mu_ndt            1.16    0.00  0.05      1.06      1.13      1.16
## transf_mu_theta          0.10    0.00  0.01      0.08      0.09      0.10
## transf_mu_delta         -0.12    0.00  0.04     -0.20     -0.14     -0.12
## transf_mu_gamma          0.74    0.00  0.02      0.70      0.72      0.74
## sd_threshold             0.95    0.00  0.10      0.79      0.89      0.95
## sd_alpha                 0.04    0.00  0.03      0.00      0.02      0.03
## sd_ndt                   0.56    0.00  0.06      0.45      0.51      0.55
## sd_theta                 0.53    0.00  0.08      0.40      0.48      0.53
## sd_gamma                 0.07    0.00  0.04      0.00      0.04      0.07
## sd_delta                 0.03    0.00  0.02      0.00      0.01      0.02
## lp__                -16195.80    0.71 17.99 -16231.54 -16208.10 -16195.71
##                          75%     97.5% n_eff Rhat
## transf_mu_alpha          0.53      0.56  2835 1.00
## transf_mu_threshold      4.15      4.32   328 1.01
## transf_mu_ndt            1.20      1.26   311 1.02
## transf_mu_theta          0.11      0.13  1387 1.00
## transf_mu_delta         -0.09     -0.04  2621 1.00
## transf_mu_gamma          0.75      0.77  2681 1.00
## sd_threshold             1.01      1.17   493 1.01
## sd_alpha                 0.05      0.11   648 1.00
## sd_ndt                   0.60      0.70   632 1.01
## sd_theta                 0.58      0.70  1062 1.00
## sd_gamma                 0.10      0.15   690 1.00
## sd_delta                 0.04      0.09  2051 1.00
## lp__                -16183.66 -16160.78   649 1.00
##
## Samples were drawn using NUTS(diag_e) at Thu Nov 16 03:12:09 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
```

```
library(ggplot2)
library(tidyverse) # for the gather function
```

```
## ── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ─
─
## ✔ forcats   1.0.0     ✔ readr     2.1.4
## ✔ lubridate 1.9.2     ✔ tibble    3.2.1
## ✔ purrr     1.0.1     ✔ tidyr     1.3.0
## ── Conflicts ────────────────────────────────────────── tidyverse_conflicts() ─
─
## ✖ tidyr::extract() masks rstan::extract()
## ✖ dplyr::filter()  masks stats::filter()
## ✖ dplyr::lag()     masks stats::lag()
## ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conf
licts to become errors
```

```
samples_matrix <- as.matrix(dsamples)
means <- colMeans(samples_matrix)
hpd_interval <- t(apply(samples_matrix, 2, function(x) quantile(x, probs=c(0.025,
0.975))))



parameters <- c("transf_mu_alpha","transf_mu_threshold","transf_mu_ndt", "transf_m
u_theta",'transf_mu_delta', 'transf_mu_gamma')

# Reshape data to a long format
df_long <- as.data.frame(samples_matrix) %>%
  gather(key = "parameter", value = "value", parameters)
```

```
## Warning: Using an external vector in selections was deprecated in tidyselect 1.
1.0.
## ℹ Please use `all_of()` or `any_of()` instead.
##   # Was:
##   data %>% select(parameters)
##
##   # Now:
##   data %>% select(all_of(parameters))
##
## See <https://tidyselect.r-lib.org/reference/faq-external-vector.html>.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
# Convert hpd_interval to a data frame and name the columns
hpd_interval_sub <- hpd_interval[parameters, ]
hpd_df <- as.data.frame(hpd_interval_sub)
colnames(hpd_df) <- c("lower", "upper")
rownames(hpd_df) <- parameters
hpd_df$parameter <- rownames(hpd_df)



# Aesthetic enhancements
theme_set(theme_minimal(base_size = 14)) # Set the default theme

custom_palette <- c("density_fill" = "lightgray",
                    "mean_line" = "blue",
                    "hpd_line" = "darkgreen")

# Add text labels for mean, lower, and upper HPD values
df_long <- df_long %>%
  group_by(parameter) %>%
  mutate(mean = means[parameter])

hpd_df <- hpd_df %>%
  mutate(mid = (lower + upper) / 2)

p <- ggplot(df_long, aes(x = value)) +
  geom_density(aes(fill = "density_fill")) +
  scale_fill_manual(values = custom_palette, guide = FALSE) +
  geom_vline(aes(xintercept = mean, color = "mean_line"), linetype = "dashed", siz
e = 1, alpha = 0.7) +
  geom_text(data = df_long, aes(x = mean, y = 0, label = round(mean, 2)), vjust =
-0.5, hjust = 0.5, size = 4, color = custom_palette["mean_line"]) +
  geom_vline(data = hpd_df, aes(xintercept = lower, color = "hpd_line"), linetype
= "solid", size = 1, alpha = 0.5) +
  geom_text(data = hpd_df, aes(x = lower, y = 0, label = round(lower, 2)), vjust =
-0.5, hjust = -0.5, size = 4, color = custom_palette["hpd_line"]) +
  geom_vline(data = hpd_df, aes(xintercept = upper, color = "hpd_line"), linetype
= "solid", size = 1, alpha = 0.5) +
  geom_text(data = hpd_df, aes(x = upper, y = 0, label = round(upper, 2)), vjust =
-0.5, hjust = 1.5, size = 4, color = custom_palette["hpd_line"]) +
  facet_wrap(~ parameter, scales = "free", ncol = 2) +
  scale_color_manual(values = custom_palette, guide = 'none') +
  labs(title = "Posterior distributions")
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## ℹ Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
print(p)
```

```
## Warning: The `guide` argument in `scale_*()` cannot be `FALSE`. This was deprec
ated in
## ggplot2 3.3.4.
## ℹ Please use "none" instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```