Sensitivity Analysis

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Contents

Introduction

This file can be used to reproduce the sensitivity analysis for our model priors, as mentioned in Chapter 4 of the thesis report.

Theoretical Concepts Descriptions

Highest Posterior Density Interval (HPDI)

Indicates which points of a distribution are most credible and summarizes the distribution by specifying an interval that spans most of it, in our case 95%. Every point inside this interval has higher credibility than points outside it.

Posterior Probability

Probability of an event occurring given the data provided. In the case of our models here, it is the probability that each of our hypotheses is likely to hold given the data used to construct them. extract.samples() method used collects given number of posterior samples from the specified model constructed.

Analysis

Required files: "Data/experience_familiarity_data.csv", "Data/sop_data.csv", "Data/ipq_DB_means.csv", "Data/cbuq_data.csv", "Data/auq_scores_data.csv".

Output: Knitted PDF (or HTML) with the same name as the script.

Importing Packages

```
library(foreign) # Open various data files
library(tidyr) # For wide to long format transformation of the data
library(ggplot2)
library(pander) # For rendering output
library(rethinking) # map2stan
```

This script performs analysis on the priors used in our models to examine their sensitivity, by testing different settings.

Experience Familiarity Elicited by the VR System

Loading Data

```
ExpFamdf = read.csv("Data/experience_familiarity_data.csv")
```

Adjusting Columns

```
ExpFamdf$subjectF <- factor(ExpFamdf$subject, levels = c(0:19), labels = c(0:19))
ExpFamdf$subjectN <- as.numeric(ExpFamdf$subject)
ExpFamdf$env_persN <- as.numeric(ExpFamdf$env_pers)
ExpFamdf$exp_famN <- as.numeric(ExpFamdf$experience_familiarity)
ExpFamdf$env_pers <- factor(ExpFamdf$env_pers)
```

Original Model

```
set.seed(42)

h1_m1 <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + b * env_persN,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    b ~ dnorm(0, 10),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h1_m1, prob=.95)
```

```
##                     mean        sd      2.5%      97.5%       n_eff      Rhat4
## v             1.5364250 0.2332270 1.1428765 2.0489236 10734.532 0.9998544
## aGeneral      2.6807669 0.2487515 2.1774689 3.1588921  8172.948 0.9999508
## b             1.3632939 0.2299759 0.9264253 1.8280839 10749.957 0.9998606
## sigma         1.0161049 0.1313532 0.7777731 1.2928415  9436.123 0.9998690
## sigmaSubjectF 0.5178861 0.1730551 0.2208934 0.8971087  4820.026 1.0000849
```

```
set.seed(42)

h1_post <-extract.samples(h1_m1, n=10000)
h1_post_prob <- length(h1_post[which(h1_post$b>0)])/length(h1_post$b)
cat("Calculated posterior probability: ",  h1_post_prob)
```

```
## Calculated posterior probability:  1
```

Expfam Normal Prior Standard Deviation = 5

```
set.seed(42)

h1_m1_lower <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + b * env_persN,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    b ~ dnorm(0, 5),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h1_m1_lower, prob=.95)
```

```
##                     mean        sd      2.5%      97.5%       n_eff      Rhat4
## v             1.5390699 0.2351230 1.1386999 2.0532485 11075.263 0.9999757
## aGeneral      2.6847031 0.2507157 2.1692164 3.1615482  7611.020 1.0001294
## b             1.3578023 0.2321003 0.9242741 1.8355284 11725.290 1.0001540
## sigma         1.0174728 0.1324748 0.7773135 1.2967024  9434.923 1.0000062
## sigmaSubjectF 0.5167344 0.1901879 0.2149669 0.8960222  2175.415 1.0006473
```

```
set.seed(42)

h1_m1_lower_post <-extract.samples(h1_m1_lower, n=10000)
h1_m1_lower_post_prob <- length(h1_m1_lower_post[which(h1_m1_lower_post$b>0)])/length(h1_m1_lower_post$b
cat("Calculated posterior probability: ",  h1_m1_lower_post_prob)
```

Calculated posterior probability: 1

```
h1_m1_lower_post_prob_diff <- h1_m1_lower_post_prob - h1_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h1_m1_lower_
```


Difference in posterior probability between this and original model: 0.00

Expfam Normal Prior Standard Deviation = 15

```
set.seed(42)

h1_m1_higher <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + b * env_persN,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    b ~ dnorm(0, 15),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h1_m1_higher, prob=.95)
```

```
##                     mean        sd      2.5%     97.5%     n_eff      Rhat4
## v             1.5438549 0.2381156 1.1444643 2.0714983 10776.535 0.9999493
## aGeneral      2.6743175 0.2510493 2.1588610 3.1468871  7088.551 1.0000379
## b             1.3677196 0.2330133 0.9276744 1.8439739 10246.657 1.0000058
## sigma         1.0204064 0.1328148 0.7785488 1.2982713  8761.951 1.0000270
## sigmaSubjectF 0.5164322 0.1858817 0.2065771 0.9017356  3428.320 1.0008525
```

```
set.seed(42)

h1_m1_higher_post <-extract.samples(h1_m1_higher, n=10000)
h1_m1_higher_post_prob <- length(h1_m1_higher_post[which(h1_m1_higher_post$b>0)])/length(h1_m1_higher_po
cat("Calculated posterior probability: ",  h1_m1_higher_post_prob)
```

Calculated posterior probability: 1

```
h1_m1_higher_post_prob_diff <- h1_m1_higher_post_prob - h1_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h1_m1_higher
```


Difference in posterior probability between this and original model: 0.00

Exponential Prior = 0.1

```
set.seed(42)

h1_m1_lower_s <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + b * env_persN,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    b ~ dnorm(0, 5),
    sigma ~ dexp(0.1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h1_m1_lower_s, prob=.95)
```

```
##                     mean        sd      2.5%     97.5%       n_eff      Rhat4
## v             1.5564835 0.2399824 1.1490516 2.094881 12129.060 1.0000491
## aGeneral      2.6736180 0.2520013 2.1579651 3.146441  9187.621 0.9999347
## b             1.3686924 0.2335557 0.9331893 1.851483 12353.080 0.9999449
## sigma         1.0318061 0.1334386 0.7905407 1.314737 10672.892 1.0001183
## sigmaSubjectF 0.5120115 0.1724151 0.2137108 0.884371  5838.394 1.0000557
```

```
set.seed(42)

h1_m1_lower_s_post <-extract.samples(h1_m1_lower_s, n=10000)
h1_m1_lower_s_post_prob <- length(h1_m1_lower_s_post[which(h1_m1_lower_s_post$b>0)])/length(h1_m1_lower_
cat("Calculated posterior probability: ",  h1_m1_lower_s_post_prob)
```

```
## Calculated posterior probability:   1
```

```
h1_m1_lower_s_post_prob_diff <- h1_m1_lower_s_post_prob - h1_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h1_m1_lower_
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Exponential Prior = 10

```
set.seed(42)

h1_m1_higher_s <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + b * env_persN,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    b ~ dnorm(0, 5),
    sigma ~ dexp(10),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h1_m1_higher_s, prob=.95)
```

```
##                     mean        sd      2.5%     97.5%       n_eff      Rhat4
```

```
## v             1.3760449 0.1994830 1.0307384 1.8139963 12366.161 0.9999072
## aGeneral      2.7811662 0.2422095 2.2886875 3.2397932  7257.214 1.0003293
## b             1.2763727 0.2168322 0.8643003 1.7164826 12059.997 1.0003427
## sigma         0.8841789 0.1131396 0.6752920 1.1186687 10239.412 0.9999071
## sigmaSubjectF 0.5365082 0.1677886 0.2709968 0.8953105  3716.523 1.0008397
```

```r
set.seed(42)

h1_m1_higher_s_post <-extract.samples(h1_m1_higher_s, n=10000)
h1_m1_higher_s_post_prob <- length(h1_m1_higher_s_post[which(h1_m1_higher_s_post$b>0)])/length(h1_m1_hig
cat("Calculated posterior probability: ",  h1_m1_higher_s_post_prob)
```

```
## Calculated posterior probability:  1
```

```r
h1_m1_higher_s_post_prob_diff <- h1_m1_higher_s_post_prob - h1_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h1_m1_highe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  h1_m1_lower
## with a difference of :  0
```

Sense of Presence Elicited by the VR System

Loading Data

```r
SoPdf = read.csv("Data/sop_data.csv")
```

Loading IGroup Database Data and Creating a Dataframe to be Used for Comparison

```r
SoPDBlist = read.csv("Data/ipq_DB_means.csv")
SoPDBdf <- data.frame( pres = SoPDBlist$X0[1],
                       sp = SoPDBlist$X0[2],
                       inv = SoPDBlist$X0[3],
                       real = SoPDBlist$X0[4]
                       )
```

Sense of Presence Models for Each Sub-Scale

General Presence

Original Model

```r
set.seed(42)

pres_m <- ulam(
  alist(
    PRES_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 10),
```

```
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(pres_m, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%    n_eff    Rhat4
## v        2.1618600 0.4472891 1.3858635 3.125292 17893.95 1.000252
## aGeneral 4.2585832 0.3013386 3.6611166 4.840538 16655.03 1.000087
## sigma    0.9746485 0.2423941 0.5832568 1.526539 16206.14 1.000059
```

```
set.seed(42)

pres_m_post <-extract.samples(pres_m, n=10000)
pres_m_post_prob <- length(pres_m_post[which(pres_m_post$aGeneral>SoPDBdf$pres)])/length(pres_m_post$aG
cat("Calculated posterior probability: ",  pres_m_post_prob)
```

```
## Calculated posterior probability:  0.9959
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

pres_m_lower <- ulam(
  alist(
    PRES_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 5),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(pres_m_lower, prob = 0.95)
```

```
##              mean        sd      2.5%     97.5%    n_eff    Rhat4
## v        2.162369 0.4470814 1.3901652 3.140557 18023.00 1.000052
## aGeneral 4.251044 0.3012237 3.6398207 4.824626 15155.28 1.000082
## sigma    0.976071 0.2452372 0.5864447 1.538441 15694.69 1.000028
```

```
set.seed(42)

pres_m_lower_post <-extract.samples(pres_m_lower, n=10000)
pres_m_lower_post_prob <- length(pres_m_lower_post[which(pres_m_lower_post$aGeneral>SoPDBdf$pres)])/len
cat("Calculated posterior probability: ",  pres_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.9961
```

```
pres_m_lower_post_prob_diff <- pres_m_lower_post_prob - pres_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(pres_m_lowe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

pres_m_higher <- ulam(
  alist(
    PRES_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 15),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(pres_m_higher, prob = 0.95)
```

```
##                mean        sd      2.5%    97.5%     n_eff     Rhat4
## v        2.1653312 0.4475939 1.3836688 3.137767 18144.67 0.9999994
## aGeneral 4.2596733 0.2975559 3.6461588 4.836458 16203.81 1.0001606
## sigma    0.9715108 0.2388404 0.5816675 1.517320 16938.52 0.9999335
```

```
set.seed(42)

pres_m_higher_post <-extract.samples(pres_m_higher, n=10000)
pres_m_higher_post_prob <- length(pres_m_higher_post[which(pres_m_higher_post$aGeneral>SoPDBdf$pres)])/
cat("Calculated posterior probability: ",  pres_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.9955
```

```
pres_m_higher_post_prob_diff <- pres_m_higher_post_prob - pres_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(pres_m_high
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  pres_m_higher
## with a difference of :  4e-04
```

Spatial Presence

Original Model

```
set.seed(42)

sp_m <- ulam(
  alist(
    SP_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 10),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
```

```
)
```

```
precis(sp_m, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff      Rhat4
## v        2.1261095 0.4397628 1.3510715  3.079484 17217.21 0.9999884
## aGeneral 3.8934645 0.2514035 3.3738137  4.363798 15681.83 0.9998846
## sigma    0.8245385 0.2133565 0.4837905  1.309687 14981.22 0.9998708
```

```
set.seed(42)

sp_m_post <-extract.samples(sp_m, n=10000)
sp_m_post_prob <- length(sp_m_post[which(sp_m_post$aGeneral>SoPDBdf$sp)])/length(sp_m_post$aGeneral)
cat("Calculated posterior probability: ",  sp_m_post_prob)
```

```
## Calculated posterior probability:  0.729
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

sp_m_lower <- ulam(
  alist(
    SP_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 5),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(sp_m_lower, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff      Rhat4
## v        2.1161295 0.4404500 1.351695  3.085276 17300.14 1.0000514
## aGeneral 3.8933159 0.2541314 3.378270  4.374989 14950.91 1.0000542
## sigma    0.8223899 0.2105346 0.485534  1.301835 15313.41 0.9999096
```

```
set.seed(42)

sp_m_lower_post <-extract.samples(sp_m_lower, n=10000)
sp_m_lower_post_prob <- length(sp_m_lower_post[which(sp_m_lower_post$aGeneral>SoPDBdf$sp)])/length(sp_m
cat("Calculated posterior probability: ",  sp_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.7221
```

```
sp_m_lower_post_prob_diff <- sp_m_lower_post_prob - sp_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(sp_m_lower_p
```

```
##
## Difference in posterior probability between this and original model:  -0.01
```

Normal Prior Standard Deviation = 15

```
set.seed(42)
```

```r
sp_m_higher <- ulam(
  alist(
    SP_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 15),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(sp_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%    97.5%     n_eff      Rhat4
## v        2.1190263 0.4447127 1.3474093 3.077482 17618.46 1.0003887
## aGeneral 3.8931096 0.2522530 3.3739651 4.364034 15914.83 0.9999675
## sigma    0.8246389 0.2134837 0.4873859 1.313335 15811.07 0.9999191
```

```r
set.seed(42)

sp_m_higher_post <-extract.samples(sp_m_higher, n=10000)
sp_m_higher_post_prob <- length(sp_m_higher_post[which(sp_m_higher_post$aGeneral>SoPDBdf$sp)])/length(sp
cat("Calculated posterior probability: ",  sp_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.7287
```

```r
sp_m_higher_post_prob_diff <- sp_m_higher_post_prob - sp_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(sp_m_higher_
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  sp_m_lower
## with a difference of :  0.0069
```

Involvement

Original Model

```r
set.seed(42)

inv_m <- ulam(
  alist(
    INV_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 10),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(inv_m, prob = 0.95)
```

```
##                mean         sd      2.5%      97.5%      n_eff       Rhat4
## v         2.1937832 0.4495761 1.4080000 3.161580 17485.91 1.0000113
## aGeneral 3.4260970 0.3027625 2.8322150 4.019669 17874.69 0.9999383
## sigma    0.9771716 0.2352430 0.5985635 1.521083 15162.54 0.9999407
```

```r
set.seed(42)

inv_m_post <-extract.samples(inv_m, n=10000)
inv_m_post_prob <- length(inv_m_post[which(inv_m_post$aGeneral>SoPDBdf$inv)])/length(inv_m_post$aGeneral
cat("Calculated posterior probability: ",  inv_m_post_prob)
```

```
## Calculated posterior probability:  0.9249
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

inv_m_lower <- ulam(
  alist(
    INV_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 5),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(inv_m_lower, prob = 0.95)
```

```
##               mean        sd      2.5%      97.5%      n_eff       Rhat4
## v         2.194907 0.4480734 1.4138541 3.166806 19125.07 0.9999504
## aGeneral 3.422487 0.3073965 2.8090086 4.015939 18185.64 0.9999751
## sigma    0.979971 0.2329016 0.6060694 1.508092 16965.74 1.0000995
```

```r
set.seed(42)

inv_m_lower_post <-extract.samples(inv_m_lower, n=10000)
inv_m_lower_post_prob <- length(inv_m_lower_post[which(inv_m_lower_post$aGeneral>SoPDBdf$inv)])/length(
cat("Calculated posterior probability: ",  inv_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.9228
```

```r
inv_m_lower_post_prob_diff <- inv_m_lower_post_prob - inv_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(inv_m_lower_
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

inv_m_higher <- ulam(
  alist(
    INV_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
```

```
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 15),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(inv_m_higher, prob = 0.95)
```

```
##                  mean        sd      2.5%     97.5%     n_eff     Rhat4
## v           2.1941549 0.4488016 1.4254224 3.160797 18668.78 0.9999548
## aGeneral    3.4253029 0.3037079 2.8298299 4.015843 17565.07 1.0000580
## sigma       0.9774129 0.2330955 0.6002826 1.502216 16288.93 0.9998982
```

```
set.seed(42)
```

```
inv_m_higher_post <-extract.samples(inv_m_higher, n=10000)
inv_m_higher_post_prob <- length(inv_m_higher_post[which(inv_m_higher_post$aGeneral>SoPDBdf$inv)])/leng
cat("Calculated posterior probability: ",  inv_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.9245
```

```
inv_m_higher_post_prob_diff <- inv_m_higher_post_prob - inv_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(inv_m_higher
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  inv_m_lower
## with a difference of :  0.0021
```

Experienced Realism

Original Model

```
set.seed(42)
```

```
real_m <- ulam(
  alist(
    REAL_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 10),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```
precis(real_m, prob = 0.95)
```

```
##                  mean        sd      2.5%     97.5%     n_eff    Rhat4
## v           2.0779784 0.4381793 1.3101663 3.032917 16587.31 1.000249
## aGeneral    2.7398988 0.2048501 2.3600258 3.169715 14740.25 1.000137
## sigma       0.6841963 0.1874721 0.3823509 1.108741 15384.21 1.000204
```

```r
set.seed(42)

real_m_post <-extract.samples(real_m, n=10000)
real_m_post_prob <- length(real_m_post[which(real_m_post$aGeneral>SoPDBdf$real)])/length(real_m_post$aG
cat("Calculated posterior probability: ",  real_m_post_prob)
```

```
## Calculated posterior probability:  0.9999
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

real_m_lower <- ulam(
  alist(
    REAL_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 5),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(real_m_lower, prob = 0.95)
```

```
##                mean        sd      2.5%     97.5%     n_eff      Rhat4
## v         2.0768034 0.4348456 1.3149777 3.015403 16459.31 0.9999558
## aGeneral  2.7388690 0.2042266 2.3607716 3.161587 13957.89 1.0001849
## sigma     0.6835638 0.1878098 0.3815262 1.116695 13806.86 1.0000700
```

```r
set.seed(42)

real_m_lower_post <-extract.samples(real_m_lower, n=10000)
real_m_lower_post_prob <- length(real_m_lower_post[which(real_m_lower_post$aGeneral>SoPDBdf$real)])/leng
cat("Calculated posterior probability: ",  real_m_lower_post_prob)
```

```
## Calculated posterior probability:  1
```

```r
real_m_lower_post_prob_diff <- real_m_lower_post_prob - real_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(real_m_lowe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

real_m_higher <- ulam(
  alist(
    REAL_Score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3, 15),
    sigma ~ dexp(1)
  ), data = SoPdf, iter = 10000, chains = 4, cores = 4
```

```
)
```

```
precis(real_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%    n_eff      Rhat4
## v       2.0806444 0.4372837 1.3341578 3.054550 15836.92 1.0000249
## aGeneral 2.7389431 0.2039256 2.3606854 3.167812 15671.74 0.9999908
## sigma    0.6827037 0.1848337 0.3834785 1.103775 15185.00 1.0001089
```

```
set.seed(42)
```

```
real_m_higher_post <-extract.samples(real_m_higher, n=10000)
real_m_higher_post_prob <- length(real_m_higher_post[which(real_m_higher_post$aGeneral>SoPDBdf$real)])/1
cat("Calculated posterior probability: ",  real_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.9999
```

```
real_m_higher_post_prob_diff <- real_m_higher_post_prob - real_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(real_m_highe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  real_m_lower
## with a difference of :  1e-04
```

Sense of Presence Subscales Effect on Experience Familiarity

General Presence

Original Model

```
set.seed(42)
```

```
h2_m0 <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_pres,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,10),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h2_m0, prob=.95)
```

```
##                   mean        sd      2.5%     97.5%    n_eff    Rhat4
## v           1.38326863 0.2126535  1.0165552 1.8485722 10786.287 1.000106
## aGeneral    3.23025619 0.6305162  1.9228670 4.4273959  6488.852 1.000837
## c           0.09645427 0.1428405 -0.1791190 0.3856597  6414.692 1.000907
```

```
## sigma        1.01224139 0.1462328  0.7451488 1.3148741  9033.922 1.000072
## sigmaSubjectF 0.58698231 0.1928130  0.2769441 0.9973876  3349.799 1.001582
```

```r
set.seed(42)

h2_m0_post <-extract.samples(h2_m0, n=10000)
h2_m0_post_prob <- length(h2_m0_post[which(h2_m0_post$c>0)])/length(h2_m0_post$c)
cat("Calculated posterior probability: ",  h2_m0_post_prob)
```

```
## Calculated posterior probability:  0.7648
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

h2_m0_lower <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_pres,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,5),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```r
precis(h2_m0_lower, prob=.95)
```

```
##                    mean        sd      2.5%     97.5%     n_eff    Rhat4
## v             1.3817751 0.2112797  1.0223260 1.8466383 11031.187 1.000047
## aGeneral      3.2171695 0.6703768  1.8551077 4.4146612  2651.973 1.001999
## c             0.0992388 0.1497312 -0.1752410 0.4052111  3410.638 1.001844
## sigma         1.0115017 0.1444149  0.7504176 1.3199422  9078.387 1.000320
## sigmaSubjectF 0.5913025 0.2196141  0.2660610 1.0357213  1500.395 1.001449
```

```r
set.seed(42)

h2_m0_lower_post <-extract.samples(h2_m0_lower, n=10000)
h2_m0_lower_post_prob <- length(h2_m0_post[which(h2_m0_lower_post$c>0)])/length(h2_m0_lower_post$c)
cat("Calculated posterior probability: ",  h2_m0_lower_post_prob)
```

```
## Calculated posterior probability:  0.7479
```

```r
h2_m0_lower_post_prob_diff <- h2_m0_lower_post_prob - h2_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h2_m0_lower_
```

```
##
## Difference in posterior probability between this and original model:  -0.02
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

h2_m0_higher <- ulam(
  alist(
```

```
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_pres,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,15),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h2_m0_higher, prob=.95)
```

```
##                     mean        sd       2.5%      97.5%      n_eff      Rhat4
## v             1.3799660 0.2090669  1.0228131 1.8366302 12370.488 0.9999459
## aGeneral      3.2277775 0.6580299  1.9065791 4.4468130  4298.370 1.0010261
## c             0.0974604 0.1477705 -0.1825917 0.3935524  4360.587 1.0008744
## sigma         1.0096809 0.1439318  0.7458091 1.3104786 10064.545 0.9999229
## sigmaSubjectF 0.5905286 0.2096113  0.2701840 1.0128964  2370.438 1.0023909
```

```
set.seed(42)

h2_m0_higher_post <-extract.samples(h2_m0_higher, n=10000)
h2_m0_higher_post_prob <- length(h2_m0_higher_post[which(h2_m0_higher_post$c>0)])/length(h2_m0_higher_p
cat("Calculated posterior probability: ",  h2_m0_higher_post_prob)
```

```
## Calculated posterior probability:  0.7606
```

```
h2_m0_higher_post_prob_diff <- h2_m0_higher_post_prob - h2_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h2_m0_highe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  h2_m0_lower
## with a difference of :  0.0169
```

Spatial Presence

Original Model

```
set.seed(42)

h3_m0 <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_sp,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,10),
    sigma ~ dexp(1),
```

```
      sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h3_m0, prob=.95)
```

```
##                    mean        sd       2.5%      97.5%      n_eff      Rhat4
## v             1.37637871 0.2112087  1.0175624 1.8438703 10459.741 0.9999066
## aGeneral      3.54542616 0.5885681  2.3366954 4.6839803  5113.802 1.0000174
## c             0.02492242 0.1532025 -0.2771121 0.3367621  5530.275 0.9998701
## sigma         1.00657532 0.1441438  0.7445660 1.3083943  8762.823 0.9998592
## sigmaSubjectF 0.60538701 0.2082446  0.2905311 1.0507749  2551.451 1.0002498
```

```
set.seed(42)

h3_m0_post <-extract.samples(h3_m0, n=10000)
h3_m0_post_prob <- length(h3_m0_post[which(h3_m0_post$c>0)])/length(h3_m0_post$c)
cat("Calculated posterior probability: ",  h3_m0_post_prob)
```

```
## Calculated posterior probability:  0.5731
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

h3_m0_lower <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_sp,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,5),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h3_m0_lower, prob=.95)
```

```
##                    mean        sd       2.5%      97.5%     n_eff     Rhat4
## v             1.37931343 0.2122537  1.0152835 1.8520448 9864.723 1.000485
## aGeneral      3.53339158 0.5751649  2.3652517 4.6491850 5831.216 1.000258
## c             0.02821347 0.1501354 -0.2639915 0.3307324 5888.736 1.000150
## sigma         1.00873996 0.1445811  0.7474517 1.3140672 8251.042 1.000355
## sigmaSubjectF 0.59657933 0.1851085  0.2887348 1.0080748 5156.265 1.000530
```

```
set.seed(42)

h3_m0_lower_post <-extract.samples(h3_m0_lower, n=10000)
h3_m0_lower_post_prob <- length(h3_m0_post[which(h3_m0_lower_post$c>0)])/length(h3_m0_lower_post$c)
cat("Calculated posterior probability: ",  h3_m0_lower_post_prob)
```

```
## Calculated posterior probability:  0.5787
```

```
h3_m0_lower_post_prob_diff <- h3_m0_lower_post_prob - h3_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h3_m0_lower
```

```
##
## Difference in posterior probability between this and original model:  0.01
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

h3_m0_higher <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_sp,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,15),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```r
precis(h3_m0_higher, prob=.95)
```

```
##                       mean        sd       2.5%      97.5%      n_eff     Rhat4
## v             1.38384655 0.2139035  1.0143924 1.8468236 11070.843 1.000019
## aGeneral      3.53535190 0.5740046  2.3672267 4.6390594  5505.035 1.000728
## c             0.02749655 0.1509664 -0.2682348 0.3263274  5646.665 1.000857
## sigma         1.01178433 0.1454654  0.7437650 1.3125523  9170.037 1.000022
## sigmaSubjectF 0.59279805 0.1844647  0.2878492 0.9962753  4832.826 1.000101
```

```r
set.seed(42)

h3_m0_higher_post <-extract.samples(h3_m0_higher, n=10000)
h3_m0_higher_post_prob <- length(h3_m0_higher_post[which(h3_m0_higher_post$c>0)])/length(h3_m0_higher_po
cat("Calculated posterior probability: ",  h3_m0_higher_post_prob)
```

```
## Calculated posterior probability:  0.5723
```

```r
h3_m0_higher_post_prob_diff <- h3_m0_higher_post_prob - h3_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h3_m0_higher
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  h3_m0_lower
## with a difference of :  0.0056
```

Involvement

Original Model

```r
set.seed(42)

h4_m0 <- ulam(
```

```
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_inv,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,10),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h4_m0, prob=.95)
```

```
##                     mean        sd       2.5%      97.5%      n_eff     Rhat4
## v             1.3802303 0.2087484  1.0235906 1.8388417 11291.579 1.000513
## aGeneral      2.9995304 0.5060054  1.9664112 3.9715184  5267.895 1.000259
## c             0.1859508 0.1351043 -0.0740286 0.4546175  5243.739 1.000248
## sigma         1.0097175 0.1439184  0.7489007 1.3128322  9456.944 1.000391
## sigmaSubjectF 0.5461040 0.1857699  0.2453599 0.9460226  4381.988 1.001535
```

```
set.seed(42)
```

```
h4_m0_post <-extract.samples(h4_m0, n=10000)
h4_m0_post_prob <- length(h4_m0_post[which(h4_m0_post$c>0)])/length(h4_m0_post$c)
cat("Calculated posterior probability: ",  h4_m0_post_prob)
```

```
## Calculated posterior probability:  0.9171
```

Normal Prior Standard Deviation = 5

```
set.seed(42)
```

```
h4_m0_lower <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_inv,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,5),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h4_m0_lower, prob=.95)
```

```
##                     mean        sd        2.5%      97.5%     n_eff     Rhat4
## v             1.3877392 0.2126520  1.02098351 1.8562505 9925.968 1.000101
## aGeneral      2.9933560 0.5033825  1.97017873 3.9474628 5086.221 1.001578
## c             0.1872688 0.1336242 -0.07228246 0.4613011 4942.477 1.001407
## sigma         1.0152757 0.1442218  0.75180295 1.3157858 7900.965 1.000503
## sigmaSubjectF 0.5407871 0.1802572  0.22382219 0.9310955 5226.125 1.001231
```

```
set.seed(42)
```

```
h4_m0_lower_post <-extract.samples(h4_m0_lower, n=10000)
h4_m0_lower_post_prob <- length(h4_m0_post[which(h4_m0_lower_post$c>0)])/length(h4_m0_lower_post$c)
cat("Calculated posterior probability: ",  h4_m0_lower_post_prob)
```

```
## Calculated posterior probability:  0.9296
```

```
h4_m0_lower_post_prob_diff <- h4_m0_lower_post_prob - h4_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h4_m0_lower_
```

```
##
## Difference in posterior probability between this and original model:  0.01
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

h4_m0_higher <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_inv,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,15),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h4_m0_higher, prob=.95)
```

```
##                    mean        sd        2.5%       97.5%      n_eff      Rhat4
## v             1.3841475 0.2102709  1.02235634 1.8437851 12490.646 1.000468
## aGeneral      2.9932243 0.5117987  1.93013312 3.9790453  5590.372 1.000313
## c             0.1876824 0.1381984 -0.07997992 0.4692503  5486.435 1.000559
## sigma         1.0133118 0.1447396  0.74769777 1.3117942  9253.633 1.000860
## sigmaSubjectF 0.5447915 0.1872524  0.23146837 0.9502621  4052.521 1.001947
```

```
set.seed(42)

h4_m0_higher_post <-extract.samples(h4_m0_higher, n=10000)
h4_m0_higher_post_prob <- length(h4_m0_higher_post[which(h4_m0_higher_post$c>0)])/length(h4_m0_higher_po
cat("Calculated posterior probability: ",  h4_m0_higher_post_prob)
```

```
## Calculated posterior probability:  0.9188
```

```
h4_m0_higher_post_prob_diff <- h4_m0_higher_post_prob - h4_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h4_m0_higher
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  h4_m0_lower
## with a difference of :  0.0125
```

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Models for the Experienced Realism Subscale

Original Model

```r
set.seed(42)

h5_m0 <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_real,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,10),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```r
precis(h5_m0, prob=.95)
```

```
##                       mean        sd        2.5%      97.5%      n_eff      Rhat4
## v             1.37869694 0.2118843  1.0128301 1.8419834 10050.277 0.9999444
## aGeneral      3.52764744 0.4997325  2.5133198 4.4890804  5782.530 1.0002727
## c             0.03692867 0.1659547 -0.2947397 0.3698802  5992.147 1.0002005
## sigma         1.00849861 0.1451480  0.7424846 1.3113179  8722.949 0.9999379
## sigmaSubjectF 0.60262964 0.1929153  0.2991171 1.0336599  4251.651 1.0009895
```

```r
set.seed(42)

h5_m0_post <-extract.samples(h5_m0, n=10000)
h5_m0_post_prob <- length(h5_m0_post[which(h5_m0_post$c>0)])/length(h5_m0_post$c)
cat("Calculated posterior probability: ",  h5_m0_post_prob)
```

```
## Calculated posterior probability:  0.5863
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

h5_m0_lower <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_real,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,5),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```r
precis(h5_m0_lower, prob=.95)
```

```
##                    mean        sd       2.5%     97.5%      n_eff     Rhat4
## v          1.38031154 0.2130545  1.0153948 1.8392534 11250.279 1.000223
## aGeneral   3.52362735 0.5062910  2.4983992 4.5010760  6026.976 1.000387
```

```
## c              0.03770042 0.1653560 -0.2893462 0.3725831  6781.597 1.000241
## sigma           1.00911500 0.1448701  0.7452738 1.3086875  9169.957 1.000488
## sigmaSubjectF 0.60207480 0.2112498  0.2910663 1.0221379  1805.868 1.001789
```

```
set.seed(42)

h5_m0_lower_post <-extract.samples(h5_m0_lower, n=10000)
h5_m0_lower_post_prob <- length(h5_m0_post[which(h5_m0_lower_post$c>0)])/length(h5_m0_lower_post$c)
cat("Calculated posterior probability: ",  h5_m0_lower_post_prob)
```

```
## Calculated posterior probability:  0.5899
```

```
h5_m0_lower_post_prob_diff <- h5_m0_lower_post_prob - h5_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h5_m0_lower
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

h5_m0_higher <- ulam(
  alist(
    exp_famN ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral + a[subjectF] * sigmaSubjectF + c * sop_real,
    aGeneral ~ dnorm(0, 10),
    a[subjectF] ~ dnorm(0, 1),
    c ~ dnorm(0,15),
    sigma ~ dexp(1),
    sigmaSubjectF ~ dexp(1)
  ), data = ExpFamdf, iter = 10000, chains = 4, cores = 4, log_lik=TRUE)
```

```
precis(h5_m0_higher, prob=.95)
```

```
##                     mean        sd      2.5%     97.5%     n_eff     Rhat4
## v             1.3809339 0.2120789  1.0208814 1.8511728 10136.388 1.000102
## aGeneral      3.5388085 0.4976479  2.5194627 4.5059903  5521.629 1.000457
## c             0.0342140 0.1649160 -0.2892746 0.3663032  5881.822 1.000348
## sigma         1.0099278 0.1451970  0.7437684 1.3066534  8611.172 1.000174
## sigmaSubjectF 0.5984391 0.1877373  0.2924331 1.0118754  4777.227 1.000492
```

```
set.seed(42)

h5_m0_higher_post <-extract.samples(h5_m0_higher, n=10000)
h5_m0_higher_post_prob <- length(h5_m0_higher_post[which(h5_m0_higher_post$c>0)])/length(h5_m0_higher_p
cat("Calculated posterior probability: ",  h5_m0_higher_post_prob)
```

```
## Calculated posterior probability:  0.5862
```

```
h5_m0_higher_post_prob_diff <- h5_m0_higher_post_prob - h5_m0_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(h5_m0_highe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  h5_m0_lower
## with a difference of :  0.0036
```

Component-Based Usability Questionnaire

Loading Data

```r
cbuq_df = read.csv("Data/cbuq_data.csv")
```

Adjusting Column

```r
cbuq_df$subjectF <- factor(cbuq_df$X, levels = c(0:19), labels = c(0:19))
```

Original Model

```r
set.seed(42)

cbuq_m <- ulam(
  alist(
    mean_score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(4, 10),
    sigma ~ dexp(1)
  ), data = cbuq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(cbuq_m, prob = 0.95)
```

```
##                mean        sd      2.5%     97.5%    n_eff     Rhat4
## v         2.0120976 0.4216895 1.2840928 2.923893 16210.8 1.0001351
## aGeneral  6.2175027 0.2053570 5.7935112 6.607977 14372.0 1.0002716
## sigma     0.6879577 0.1920087 0.3890169 1.136467 14135.7 0.9999291
```

```r
set.seed(42)

cbuq_m_post <-extract.samples(cbuq_m, n=10000)
cbuq_m_post_prob <- length(cbuq_m_post[which(cbuq_m_post$aGeneral>5.29)])/length(cbuq_m_post$aGeneral)
cat("Calculated posterior probability: ",  cbuq_m_post_prob)
```

```
## Calculated posterior probability:  1
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

cbuq_m_lower <- ulam(
  alist(
    mean_score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
```

```
    aGeneral ~ dnorm(4, 5),
    sigma ~ dexp(1)
  ), data = cbuq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(cbuq_m_lower, prob = 0.95)
```

```
##              mean        sd      2.5%     97.5%    n_eff    Rhat4
## v        2.015120 0.4260767 1.2814228 2.939990 16271.28 1.000286
## aGeneral 6.213641 0.2049409 5.7930101 6.604699 14384.33 0.999923
## sigma    0.685843 0.1929778 0.3842079 1.132246 14311.90 1.000003
```

```
set.seed(42)

cbuq_m_lower_post <-extract.samples(cbuq_m_lower, n=10000)
cbuq_m_lower_post_prob <- length(cbuq_m_lower_post[which(cbuq_m_lower_post$aGeneral>5.29)])/length(cbuq
cat("Calculated posterior probability: ", cbuq_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.9992
```

```
cbuq_m_lower_post_prob_diff <- cbuq_m_lower_post_prob - cbuq_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(cbuq_m_lower
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

cbuq_m_higher <- ulam(
  alist(
    mean_score ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(4, 15),
    sigma ~ dexp(1)
  ), data = cbuq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(cbuq_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%    n_eff     Rhat4
## v        2.0177726 0.4214162 1.2862526 2.934219 16385.80 0.9999566
## aGeneral 6.2188013 0.2073810 5.7828774 6.611961 15116.24 1.0002331
## sigma    0.6895869 0.1944156 0.3873616 1.138790 15256.60 0.9999164
```

```
set.seed(42)

cbuq_m_higher_post <-extract.samples(cbuq_m_higher, n=10000)
cbuq_m_higher_post_prob <- length(cbuq_m_higher_post[which(cbuq_m_higher_post$aGeneral>5.29)])/length(cb
cat("Calculated posterior probability: ", cbuq_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.9996
```

```
cbuq_m_higher_post_prob_diff <- cbuq_m_higher_post_prob - cbuq_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(cbuq_m_highe
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  cbuq_m_lower
## with a difference of :  8e-04
```

Additional Usability Questions

Loading Data

```
auq_df = read.csv("Data/auq_scores_data.csv")
```

Adjusting Column

```
auq_df$subjectF <- factor(auq_df$X, levels = c(0:19), labels = c(0:19))
```

AUQ 1

Original Model

```
set.seed(42)

auq_q1_m <- ulam(
  alist(
    Q1 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q1_m, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%    n_eff    Rhat4
## v         1.968155 0.4398090 1.2200182 2.925249 13196.42 1.000092
## aGeneral 3.039658 0.3782011 2.1928221 3.705107 10646.08 1.000171
## sigma    1.207220 0.3735259 0.6229883 2.071443 11399.91 1.000236
```

```
set.seed(42)

auq_q1_m_post <-extract.samples(auq_q1_m, n=10000)
auq_q1_m_post_prob <- length(auq_q1_m_post[which(auq_q1_m_post$aGeneral>0)])/length(auq_q1_m_post$aGene
cat("Calculated posterior probability: ",  auq_q1_m_post_prob)
```

```
## Calculated posterior probability:  1
```

Normal Prior Standard Deviation = 5

```
set.seed(42)
```

```r
auq_q1_m_lower <- ulam(
  alist(
    Q1 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q1_m_lower, prob = 0.95)
```

```
##             mean        sd      2.5%     97.5%     n_eff      Rhat4
## v       1.965198 0.4339417 1.2214608 2.899460 13907.41 0.9998609
## aGeneral 3.037121 0.3701779 2.2216415 3.693350 11722.74 1.0001114
## sigma   1.205974 0.3748352 0.6191057 2.074844 10883.59 1.0001255
```

```r
set.seed(42)

auq_q1_m_lower_post <-extract.samples(auq_q1_m_lower, n=10000)
auq_q1_m_lower_post_prob <- length(auq_q1_m_lower_post[which(auq_q1_m_lower_post$aGeneral>0)])/length(au
cat("Calculated posterior probability: ",  auq_q1_m_lower_post_prob)
```

```
## Calculated posterior probability:   1
```

```r
auq_q1_m_lower_post_prob_diff <- auq_q1_m_lower_post_prob - auq_q1_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q1_m_lo
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

auq_q1_m_higher <- ulam(
  alist(
    Q1 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q1_m_higher, prob = 0.95)
```

```
##             mean        sd      2.5%     97.5%     n_eff     Rhat4
## v       1.960448 0.4302714 1.2247678 2.894476 13733.66 1.000084
## aGeneral 3.039436 0.3712024 2.2133068 3.696103 11463.39 1.000095
## sigma   1.204916 0.3717143 0.6211961 2.062283 11619.68 1.000069
```

```r
set.seed(42)

auq_q1_m_higher_post <-extract.samples(auq_q1_m_higher, n=10000)
auq_q1_m_higher_post_prob <- length(auq_q1_m_higher_post[which(auq_q1_m_higher_post$aGeneral>0)])/length
```

```r
cat("Calculated posterior probability: ",  auq_q1_m_higher_post_prob)
```

```
## Calculated posterior probability:   1
```

```r
auq_q1_m_higher_post_prob_diff <- auq_q1_m_higher_post_prob - auq_q1_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q1_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q1_m_lower
## with a difference of :  0
```

AUQ 2

Original Model

```r
set.seed(42)

auq_q2_m <- ulam(
  alist(
    Q2 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q2_m, prob = 0.95)
```

```
##                  mean           sd        2.5%        97.5%         n_eff     Rhat4
## v        4.061697e-01 6.218131e-02 2.788303e-01 4.669648e-01      2.077425 7.080056
## aGeneral 5.000000e+00 2.030327e-07 5.000000e+00 5.000000e+00 19357.009570 1.000224
## sigma    1.128157e-06 4.476766e-07 5.495728e-07 1.953186e-06      3.029288 2.410521
```

```r
set.seed(42)

auq_q2_m_post <-extract.samples(auq_q2_m, n=10000)
auq_q2_m_post_prob <- length(auq_q2_m_post[which(auq_q2_m_post$aGeneral>3.5)])/length(auq_q2_m_post$aGen
cat("Calculated posterior probability: ",  auq_q2_m_post_prob)
```

```
## Calculated posterior probability:   1
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

auq_q2_m_lower <- ulam(
  alist(
    Q2 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
```

```
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q2_m_lower, prob = 0.95)
```

```
##                   mean           sd         2.5%          97.5%        n_eff      Rhat4
## v         3.487088e-01 6.942089e-02 0.2499766022 4.500362e-01     2.001729 45.995614
## aGeneral  5.000000e+00 2.063551e-07 4.9999995692 5.000000e+00 18714.998446  1.000062
## sigma     1.147182e-06 5.051183e-07 0.0000004307 1.935336e-06     3.139616  2.360540
```

```
set.seed(42)

auq_q2_m_lower_post <-extract.samples(auq_q2_m_lower, n=10000)
auq_q2_m_lower_post_prob <- length(auq_q2_m_lower_post[which(auq_q2_m_lower_post$aGeneral>3.5)])/length
cat("Calculated posterior probability: ",  auq_q2_m_lower_post_prob)
```

```
## Calculated posterior probability:  1
```

```
auq_q2_m_lower_post_prob_diff <- auq_q2_m_lower_post_prob - auq_q2_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q2_m_low
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

auq_q2_m_higher <- ulam(
  alist(
    Q2 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q2_m_higher, prob = 0.95)
```

```
##                   mean           sd         2.5%        97.5%        n_eff      Rhat4
## v         4.004924e-01 1.008365e-01 3.022037e-01 5.741858e-01     2.007651 17.9350897
## aGeneral  5.000000e+00 1.898460e-07 5.000000e+00 5.000000e+00 17458.610793  0.9999645
## sigma     9.100226e-07 5.673602e-07 2.586380e-07 2.467235e-06     3.012900  2.4341528
```

```
set.seed(42)

auq_q2_m_higher_post <-extract.samples(auq_q2_m_higher, n=10000)
auq_q2_m_higher_post_prob <- length(auq_q2_m_higher_post[which(auq_q2_m_higher_post$aGeneral>3.5)])/leng
cat("Calculated posterior probability: ",  auq_q2_m_higher_post_prob)
```

```
## Calculated posterior probability:  1
```

```
auq_q2_m_higher_post_prob_diff <- auq_q2_m_higher_post_prob - auq_q2_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q2_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q2_m_lower
## with a difference of :  0
```

AUQ 3

Original Model

```
set.seed(42)

auq_q3_m <- ulam(
  alist(
    Q3 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q3_m, prob=.95 )
```

```
##              mean        sd     2.5%     97.5%     n_eff    Rhat4
## v        2.160768 0.4513205 1.375427 3.144425 17105.81 0.99990
## aGeneral 2.903661 0.5357926 1.800799 3.880886 13957.87 1.00004
## sigma    1.631740 0.3991508 0.981033 2.531659 15265.66 1.00001
```

```
set.seed(42)

auq_q3_m_post <-extract.samples(auq_q3_m, n=10000)
auq_q3_m_post_prob <- length(auq_q3_m_post[which(auq_q3_m_post$aGeneral>0)])/length(auq_q3_m_post$aGene
cat("Calculated posterior probability: ",  auq_q3_m_post_prob)
```

```
## Calculated posterior probability:  1
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

auq_q3_m_lower <- ulam(
  alist(
    Q3 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
```

```
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q3_m_lower, prob = 0.95)
```

```
##              mean        sd      2.5%     97.5%    n_eff       Rhat4
## v        2.160924 0.4487416 1.3929492 3.134684 16858.38 1.0000098
## aGeneral 2.874690 0.5335745 1.7697990 3.853125 15653.83 0.9999206
## sigma    1.634186 0.3972245 0.9864526 2.541631 14908.74 0.9999148
```

```
set.seed(42)

auq_q3_m_lower_post <-extract.samples(auq_q3_m_lower, n=10000)
auq_q3_m_lower_post_prob <- length(auq_q3_m_lower_post[which(auq_q3_m_lower_post$aGeneral>0)])/length(au
cat("Calculated posterior probability: ",  auq_q3_m_lower_post_prob)
```

```
## Calculated posterior probability:  1
```

```
auq_q3_m_lower_post_prob_diff <- auq_q3_m_lower_post_prob - auq_q3_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q3_m_lo
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

auq_q3_m_higher <- ulam(
  alist(
    Q3 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q3_m_higher, prob = 0.95)
```

```
##              mean        sd      2.5%     97.5%    n_eff       Rhat4
## v        2.162114 0.4465287 1.3872613 3.148329 15913.95 0.9999677
## aGeneral 2.900658 0.5317629 1.7910011 3.882477 14824.55 0.9998436
## sigma    1.627266 0.3930733 0.9824786 2.505243 15310.09 1.0001288
```

```
set.seed(42)

auq_q3_m_higher_post <-extract.samples(auq_q3_m_higher, n=10000)
auq_q3_m_higher_post_prob <- length(auq_q3_m_higher_post[which(auq_q3_m_higher_post$aGeneral>0)])/lengt
cat("Calculated posterior probability: ",  auq_q3_m_higher_post_prob)
```

```
## Calculated posterior probability:  1
```

```
auq_q3_m_higher_post_prob_diff <- auq_q3_m_higher_post_prob - auq_q3_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q3_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```
cat("The largest difference detected between the original model\nand the models using the above prior w
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q3_m_lower
## with a difference of :  0
```

AUQ 4

Original Model

```
set.seed(42)

auq_q4_m <- ulam(
  alist(
    Q4 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q4_m, prob=.95 )
```

```
##               mean        sd      2.5%     97.5%     n_eff      Rhat4
## v         2.123650 0.4510796 1.3333704 3.088709 14759.31 0.9999998
## aGeneral  2.518611 0.4930605 1.4559561 3.396141 12665.86 1.0001686
## sigma     1.518402 0.4014537 0.8506389 2.421833 12966.27 1.0001563
```

```
set.seed(42)

auq_q4_m_post <-extract.samples(auq_q4_m, n=10000)
auq_q4_m_post_prob <- length(auq_q4_m_post[which(auq_q4_m_post$aGeneral>0)])/length(auq_q4_m_post$aGener
cat("Calculated posterior probability: ",  auq_q4_m_post_prob)
```

```
## Calculated posterior probability:  0.9999
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

auq_q4_m_lower <- ulam(
  alist(
    Q4 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q4_m_lower, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff     Rhat4
## v         2.136457 0.4622473 1.3392435 3.134471 14890.29 1.000117
```

```
## aGeneral 2.490250 0.4927214 1.4232417 3.355283 12542.29 1.000082
## sigma    1.526619 0.3949770 0.8513761 2.404615 12718.26 1.000181
```

```r
set.seed(42)

auq_q4_m_lower_post <-extract.samples(auq_q4_m_lower, n=10000)
auq_q4_m_lower_post_prob <- length(auq_q4_m_lower_post[which(auq_q4_m_lower_post$aGeneral>0)])/length(au
cat("Calculated posterior probability: ",  auq_q4_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.9999
```

```r
auq_q4_m_lower_post_prob_diff <- auq_q4_m_lower_post_prob - auq_q4_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q4_m_lou
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

auq_q4_m_higher <- ulam(
  alist(
    Q4 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q4_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff     Rhat4
## v        2.135995 0.4506890 1.3514870 3.107110 15256.90 0.9999911
## aGeneral 2.517956 0.4907465 1.4480628 3.385920 13864.78 0.9999261
## sigma    1.521568 0.3976359 0.8422075 2.399767 13273.80 0.9999408
```

```r
set.seed(42)

auq_q4_m_higher_post <-extract.samples(auq_q4_m_higher, n=10000)
auq_q4_m_higher_post_prob <- length(auq_q4_m_higher_post[which(auq_q4_m_higher_post$aGeneral>0)])/length
cat("Calculated posterior probability: ",  auq_q4_m_higher_post_prob)
```

```
## Calculated posterior probability:  1
```

```r
auq_q4_m_higher_post_prob_diff <- auq_q4_m_higher_post_prob - auq_q4_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q4_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q4_m_higher
## with a difference of :  1e-04
```

AUQ 5

Original Model

```
set.seed(42)

auq_q5_m <- ulam(
  alist(
    Q5 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q5_m, prob=.95 )
```

```
##               mean        sd      2.5%     97.5%     n_eff      Rhat4
## v         2.085842 0.4381796 1.3303386 3.033832 16744.12 1.0000331
## aGeneral 2.546053 0.4548101 1.5829583 3.378777 14584.98 1.0005081
## sigma     1.465800 0.3816181 0.8534114 2.350452 14387.55 0.9999901
```

```
set.seed(42)

auq_q5_m_post <-extract.samples(auq_q5_m, n=10000)
auq_q5_m_post_prob <- length(auq_q5_m_post[which(auq_q5_m_post$aGeneral>0)])/length(auq_q5_m_post$aGene
cat("Calculated posterior probability: ",  auq_q5_m_post_prob)
```

```
## Calculated posterior probability:   1
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

auq_q5_m_lower <- ulam(
  alist(
    Q5 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q5_m_lower, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff     Rhat4
## v         2.091001 0.4377332 1.3351618 3.036170 15420.52 1.000131
## aGeneral 2.529478 0.4607733 1.5757737 3.370583 14006.74 1.000097
## sigma     1.470587 0.3846448 0.8528981 2.341039 14355.82 0.999915
```

```
set.seed(42)

auq_q5_m_lower_post <-extract.samples(auq_q5_m_lower, n=10000)
auq_q5_m_lower_post_prob <- length(auq_q5_m_lower_post[which(auq_q5_m_lower_post$aGeneral>0)])/length(au
```

```r
cat("Calculated posterior probability: ",  auq_q5_m_lower_post_prob)
```

```
## Calculated posterior probability:  1
```

```r
auq_q5_m_lower_post_prob_diff <- auq_q5_m_lower_post_prob - auq_q5_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q5_m_low
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

auq_q5_m_higher <- ulam(
  alist(
    Q5 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q5_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%    n_eff      Rhat4
## v         2.080994 0.4410895 1.3249306 3.037759 17171.79 1.0001738
## aGeneral  2.548767 0.4562972 1.5973237 3.380507 14776.04 1.0001484
## sigma     1.460613 0.3801170 0.8481418 2.309755 15257.96 0.9998366
```

```r
set.seed(42)

auq_q5_m_higher_post <-extract.samples(auq_q5_m_higher, n=10000)
auq_q5_m_higher_post_prob <- length(auq_q5_m_higher_post[which(auq_q5_m_higher_post$aGeneral>0)])/lengtl
cat("Calculated posterior probability: ",  auq_q5_m_higher_post_prob)
```

```
## Calculated posterior probability:  1
```

```r
auq_q5_m_higher_post_prob_diff <- auq_q5_m_higher_post_prob - auq_q5_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q5_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q5_m_lower
## with a difference of :  0
```

AUQ 6

Original Model

```
set.seed(42)

auq_q6_m <- ulam(
  alist(
    Q6 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q6_m, prob=.95 )
```

```
##               mean        sd     2.5%     97.5%    n_eff     Rhat4
## v        2.048268 0.4459502 1.276830 3.021833 12524.23 0.9999228
## aGeneral 2.802658 0.7005480 1.251896 4.022122 11639.74 0.9998631
## sigma    2.109946 0.5905410 1.150094 3.438708 11003.63 1.0001521
```

```
set.seed(42)

auq_q6_m_post <-extract.samples(auq_q6_m, n=10000)
auq_q6_m_post_prob <- length(auq_q6_m_post[which(auq_q6_m_post$aGeneral>0)])/length(auq_q6_m_post$aGener
cat("Calculated posterior probability: ",  auq_q6_m_post_prob)
```

```
## Calculated posterior probability:  0.999
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

auq_q6_m_lower <- ulam(
  alist(
    Q6 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q6_m_lower, prob = 0.95)
```

```
##               mean        sd     2.5%     97.5%    n_eff     Rhat4
## v        2.058245 0.4507092 1.281431 3.037807 13881.14 0.9998778
## aGeneral 2.762679 0.7088350 1.189725 3.992786 11055.59 1.0001113
## sigma    2.124294 0.5870972 1.159965 3.442427 11957.20 1.0002237
```

```
set.seed(42)

auq_q6_m_lower_post <-extract.samples(auq_q6_m_lower, n=10000)
auq_q6_m_lower_post_prob <- length(auq_q6_m_lower_post[which(auq_q6_m_lower_post$aGeneral>0)])/length(au
```

```r
cat("Calculated posterior probability: ",  auq_q6_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.9994
```

```r
auq_q6_m_lower_post_prob_diff <- auq_q6_m_lower_post_prob - auq_q6_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q6_m_lo
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

Normal Prior Standard Deviation = 15

```r
set.seed(42)

auq_q6_m_higher <- ulam(
  alist(
    Q6 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(auq_q6_m_higher, prob = 0.95)
```

```
##               mean        sd     2.5%    97.5%     n_eff     Rhat4
## v         2.051820 0.4442388 1.287184 3.015945 13001.11 0.9999386
## aGeneral  2.804651 0.7067564 1.209761 4.030619 11630.11 0.9999386
## sigma     2.109622 0.5812699 1.150291 3.395419 11960.29 1.0000351
```

```r
set.seed(42)

auq_q6_m_higher_post <-extract.samples(auq_q6_m_higher, n=10000)
auq_q6_m_higher_post_prob <- length(auq_q6_m_higher_post[which(auq_q6_m_higher_post$aGeneral>0)])/lengt
cat("Calculated posterior probability: ",  auq_q6_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.9993
```

```r
auq_q6_m_higher_post_prob_diff <- auq_q6_m_higher_post_prob - auq_q6_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q6_m_hig
```

```
##
## Difference in posterior probability between this and original model:  0.00
```

```r
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  auq_q6_m_lower
## with a difference of :  4e-04
```

AUQ 7

Original Model

```
set.seed(42)

auq_q7_m <- ulam(
  alist(
    Q7 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q7_m, prob=.95 )
```

```
##               mean        sd      2.5%    97.5%    n_eff     Rhat4
## v        2.208042 0.4526031 1.4222644 3.186175 18607.53 0.9999765
## aGeneral 2.332390 0.3906897 1.5419722 3.075577 16514.65 1.0001010
## sigma    1.230384 0.2898381 0.7592474 1.881647 16714.36 1.0000771
```

```
set.seed(42)

auq_q7_m_post <-extract.samples(auq_q7_m, n=10000)
auq_q7_m_post_prob <- length(auq_q7_m_post[which(auq_q7_m_post$aGeneral>3.5)])/length(auq_q7_m_post$aGe
cat("Calculated posterior probability: ",  auq_q7_m_post_prob)
```

```
## Calculated posterior probability:  0.0012
```

Normal Prior Standard Deviation = 5

```
set.seed(42)

auq_q7_m_lower <- ulam(
  alist(
    Q7 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q7_m_lower, prob = 0.95)
```

```
##               mean        sd      2.5%    97.5%    n_eff     Rhat4
## v        2.204194 0.4524514 1.4138755 3.182842 18950.87 0.9999473
## aGeneral 2.338498 0.3871408 1.5515281 3.073821 17842.12 1.0000769
## sigma    1.226155 0.2880384 0.7521345 1.886691 16079.37 0.9999396
```

```
set.seed(42)

auq_q7_m_lower_post <-extract.samples(auq_q7_m_lower, n=10000)
auq_q7_m_lower_post_prob <- length(auq_q7_m_lower_post[which(auq_q7_m_lower_post$aGeneral>3.5)])/length
```

```
cat("Calculated posterior probability: ",  auq_q7_m_lower_post_prob)
```

Calculated posterior probability: 0.0014

```
auq_q7_m_lower_post_prob_diff <- auq_q7_m_lower_post_prob - auq_q7_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q7_m_lo
```

##
Difference in posterior probability between this and original model: 0.00

Normal Prior Standard Deviation = 15

```
set.seed(42)

auq_q7_m_higher <- ulam(
  alist(
    Q7 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(3.5, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(auq_q7_m_higher, prob = 0.95)
```

```
##               mean        sd      2.5%     97.5%     n_eff     Rhat4
## v         2.202105 0.4544245 1.4178536 3.177772 17892.95 0.9999698
## aGeneral 2.329374 0.3934848 1.5314452 3.073515 17253.21 1.0002887
## sigma    1.233055 0.2942107 0.7557491 1.913053 15671.67 0.9999134
```

```
set.seed(42)

auq_q7_m_higher_post <-extract.samples(auq_q7_m_higher, n=10000)
auq_q7_m_higher_post_prob <- length(auq_q7_m_higher_post[which(auq_q7_m_higher_post$aGeneral>3.5)])/len
cat("Calculated posterior probability: ",  auq_q7_m_higher_post_prob)
```

Calculated posterior probability: 0.0013

```
auq_q7_m_higher_post_prob_diff <- auq_q7_m_higher_post_prob - auq_q7_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(auq_q7_m_hi
```

##
Difference in posterior probability between this and original model: 0.00

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

The largest difference detected between the original model
and the models using the above prior was: auq_q7_m_lower
with a difference of : 2e-04

Ease of Material Collection Question

Original Model

```r
set.seed(42)

eomc_m <- ulam(
  alist(
    Q8 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 10),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(eomc_m, prob=.95 )
```

```
##                mean        sd       2.5%     97.5%     n_eff      Rhat4
## v         2.1540493 0.4475017  1.3815591 3.113640 16198.77 0.9999251
## aGeneral  0.2054679 0.6108456 -0.9705473 1.449682 16298.00 0.9999200
## sigma     1.9437994 0.4690960  1.1660896 2.999478 14804.63 0.9999441
```

```r
set.seed(42)

eomc_m_post <-extract.samples(eomc_m, n=10000)
eomc_m_post_prob <- length(eomc_m_post[which(eomc_m_post$aGeneral>0)])/length(eomc_m_post$aGeneral)
cat("Calculated posterior probability: ",  eomc_m_post_prob)
```

```
## Calculated posterior probability:  0.6333
```

Normal Prior Standard Deviation = 5

```r
set.seed(42)

eomc_m_lower <- ulam(
  alist(
    Q8 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 5),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```r
precis(eomc_m_lower, prob = 0.95)
```

```
##               mean        sd       2.5%     97.5%     n_eff      Rhat4
## v         2.157394 0.4489256  1.3789961 3.135117 17051.33 0.9998886
## aGeneral  0.220665 0.6141847 -0.9327719 1.493828 15464.90 1.0003488
## sigma     1.949456 0.4674023  1.1791484 3.003843 16142.90 0.9999188
```

```r
set.seed(42)

eomc_m_lower_post <-extract.samples(eomc_m_lower, n=10000)
eomc_m_lower_post_prob <- length(eomc_m_lower_post[which(eomc_m_lower_post$aGeneral>0)])/length(eomc_m_
```

```
cat("Calculated posterior probability: ",  eomc_m_lower_post_prob)
```

```
## Calculated posterior probability:  0.6405
```

```
eomc_m_lower_post_prob_diff <- eomc_m_lower_post_prob - eomc_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(eomc_m_lower
```

```
##
## Difference in posterior probability between this and original model:  0.01
```

Normal Prior Standard Deviation = 15

```
set.seed(42)

eomc_m_higher <- ulam(
  alist(
    Q8 ~ dstudent(v, mu, sigma),
    v ~ gamma(2,0.1),
    mu <- aGeneral,
    aGeneral ~ dnorm(0, 15),
    sigma ~ dexp(1)
  ), data = auq_df, iter = 10000, chains = 4, cores = 4
)
```

```
precis(eomc_m_higher, prob = 0.95)
```

```
##                 mean        sd       2.5%     97.5%     n_eff      Rhat4
## v          2.1524951 0.4432611  1.3873793 3.111993 17138.77 1.0000310
## aGeneral   0.2105113 0.6254511 -0.9832049 1.500410 16519.34 1.0001210
## sigma      1.9488163 0.4717227  1.1638465 3.009127 15105.92 0.9999492
```

```
set.seed(42)

eomc_m_higher_post <-extract.samples(eomc_m_higher, n=10000)
eomc_m_higher_post_prob <- length(eomc_m_higher_post[which(eomc_m_higher_post$aGeneral>0)])/length(eomc_
cat("Calculated posterior probability: ",  eomc_m_higher_post_prob)
```

```
## Calculated posterior probability:  0.6248
```

```
eomc_m_higher_post_prob_diff <- eomc_m_higher_post_prob - eomc_m_post_prob
cat("\nDifference in posterior probability between this and original model: ", format(round(eomc_m_highe
```

```
##
## Difference in posterior probability between this and original model:  -0.01
```

```
cat("The largest difference detected between the original model\nand the models using the above prior wa
```

```
## The largest difference detected between the original model
## and the models using the above prior was:  eomc_m_higher
## with a difference of :  0.0085
```