Preregistered Analysis MARP

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Here, we report the results of our own preregistered analysis for the MARP data. The preregistration can be found at https://osf.io/zyu8c/.

Prepare Data

Load data

```
dat <- read.csv("../data/MARP_data.csv")
```

Preprocess data

- exclude attention check failures
- create averages of the religiosity items (item 1, 2, 3, 5, 6, 7) and of the cultural norms items (item 1 and 2).

```
# exclude attention check failures
dat <- dat[dat$attention_check==1,]
# create means for religiosity and cultural norms (all rel items except item 4)
dat$rel_mean <- rowMeans(dat[,grepl('rel_', colnames(dat))&colnames(dat)!="rel_4"])
dat$cnorm_mean <- rowMeans(dat[,c("cnorm_1","cnorm_2")])
```

Standardize variables

- standardize predictors, outcome, and continuous covariates ('age' is centered and rescaled as decades to facilitate interpretation)

```
std.cols <- c('ses', 'education', 'rel_mean', 'cnorm_mean','wb_overall_mean')
dat[,std.cols] <- apply(dat[,std.cols], 2, function(x) scale(x, center = T, scale = T)[,1])
dat$age <- scale(dat$age, center=T, scale=F)[,1]/10
```

```
analysis.cols <- c('ses', 'education', 'age', 'gender', 'rel_mean', 'cnorm_mean',
                   'wb_overall_mean', 'gdp_scaled')
dat <- dat[complete.cases(dat[,analysis.cols]),]
```

Main Models

Note that it takes quite a while to run the code and get the Stan models.

Settings

```r
iterations = 20000
warmup = 5000
chains = 4
```

Hypothesis 1: is there a positive association between religiosity and well-being?

```r
m0 <- brm(data = dat, family = gaussian(),
          formula = wb_overall_mean ~ 1 + age + gender + ses + education + (1 | country),
          prior = c(prior(normal(0, 10), class = Intercept),
                    prior(normal(0, 1), class = b),
                    prior(cauchy(0, 2), class = sd),
                    prior(cauchy(0, 10), class = sigma)),
          save_pars = save_pars(all = TRUE),
          iter = iterations, warmup = warmup, chains = chains, cores = 4, seed = 2021)

m1 <- brm(data = dat, family = gaussian(),
          wb_overall_mean ~ 1 + age + gender + ses + education + rel_mean + (1 + rel_mean | country),
          prior = c(prior(normal(0, 10), class = Intercept),
                    prior(normal(0, 1), class = b),
                    prior(cauchy(0, 2), class = sd),
                    prior(cauchy(0, 10), class = sigma),
                    prior(lkj(4), class = cor)),
          save_pars = save_pars(all = TRUE),
          iter = iterations, warmup = warmup, chains = chains, cores = 4, seed = 2021)
```

```r
print(summary(m1), digits=3)
```

```
##  Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: wb_overall_mean ~ 1 + age + gender + ses + education + rel_mean + (1 + rel_mean | country)
##    Data: dat (Number of observations: 10170)
##   Draws: 4 chains, each with iter = 20000; warmup = 5000; thin = 1;
##          total post-warmup draws = 60000
##
## Group-Level Effects:
## ~country (Number of levels: 24)
##                           Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS
## sd(Intercept)                0.213     0.035    0.156    0.292 1.000    16685
## sd(rel_mean)                 0.052     0.016    0.024    0.085 1.000    24261
## cor(Intercept,rel_mean)     -0.401     0.219   -0.769    0.075 1.000    51850
##                           Tail_ESS
## sd(Intercept)                29051
## sd(rel_mean)                 29156
## cor(Intercept,rel_mean)      45403
##
## Population-Level Effects:
##              Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS Tail_ESS
## Intercept      -0.002     0.046   -0.093    0.090 1.000     9844    18380
## age             0.023     0.008    0.007    0.038 1.000    72860    46459
## genderother    -0.516     0.115   -0.742   -0.289 1.000    93389    43257
## genderwoman    -0.052     0.019   -0.089   -0.015 1.000    85211    44805
## ses             0.364     0.010    0.345    0.383 1.000    83133    45436
## education       0.066     0.010    0.047    0.085 1.000    80984    44641
## rel_mean        0.112     0.015    0.082    0.141 1.000    31496    38568
```

```
##
## Family Specific Parameters:
##       Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS Tail_ESS
## sigma    0.873     0.006    0.861    0.885 1.000    92162    43851
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

```
# coefficients for the religiosity predictor
summary(m1)$fixed['rel_mean',]
```

```
##           Estimate  Est.Error   l-95% CI  u-95% CI     Rhat Bulk_ESS Tail_ESS
## rel_mean 0.1118801 0.01496071 0.08231384 0.1414124 1.000114 31495.67 38568.18
```

```
# Bayes factor for the inclusion of religiosity as a varying effect
bf10 <- bayes_factor(m1,m0)
```

```
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
```

```
bf10
```

```
## Estimated Bayes factor in favor of m1 over m0: 28683158323019374694026444 8.00000
```

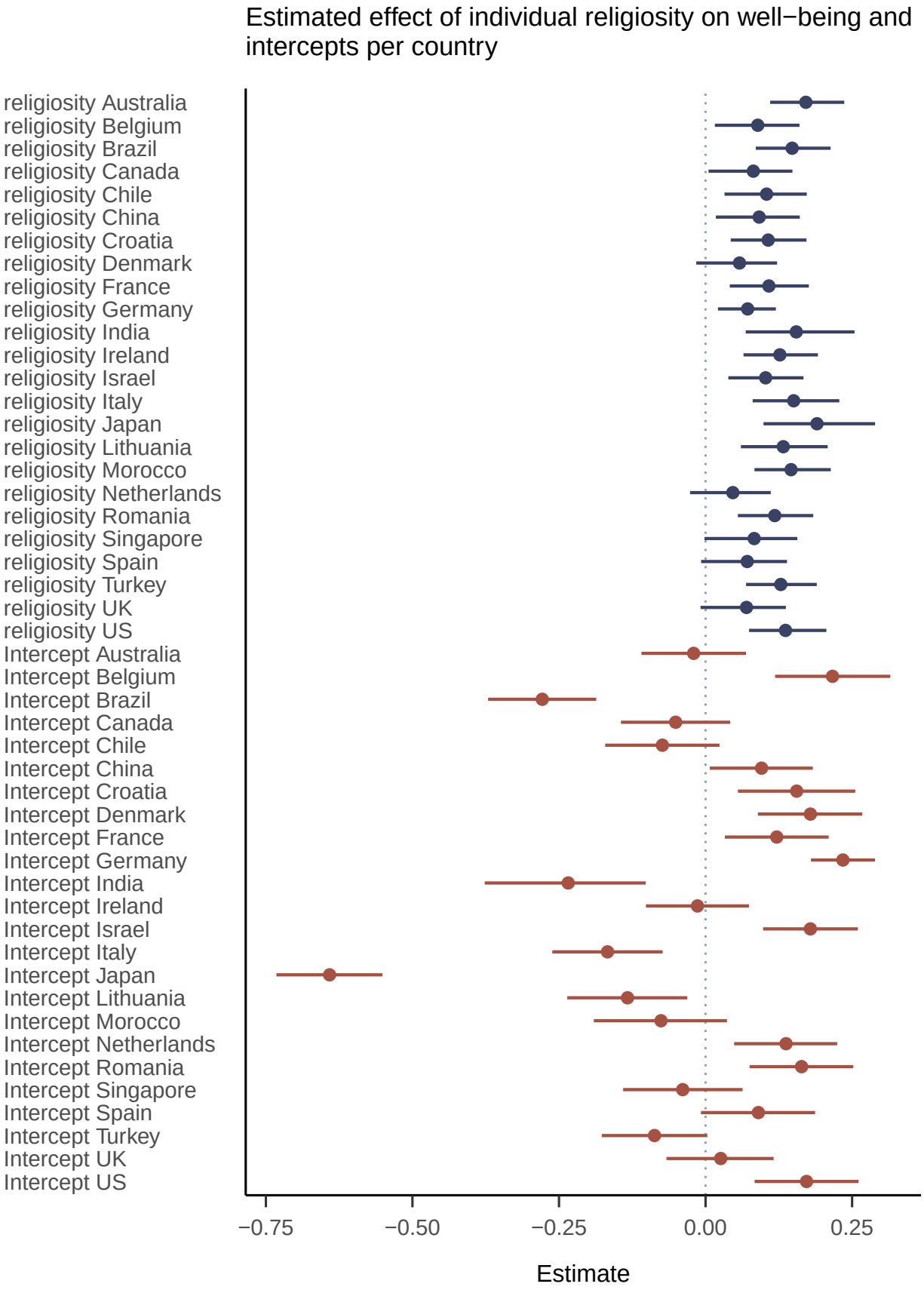
```
# Posterior model probability
pp10 <- post_prob(m1,m0)
```

```
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
```

```
pp10
```

```
##           m1           m0
## 1.000000e+00 3.436593e-27
```

For research question 1, we find strong evidence that religiosity is positively related to well-being: BF_{10} = 2.9e+26, posterior model probability is 1.00 for $\mathcal{M}_1$ and 0.00 for $\mathcal{M}_0$, the standardized estimate (beta) of the religiosity coefficient is 0.112, 95% credible interval [0.082, 0.141].


Estimated effect of individual religiosity on well−being and intercepts per country
religiosity Australia
religiosity Belgium
religiosity Brazil
religiosity Canada
religiosity Chile
religiosity China
religiosity Croatia
religiosity Denmark
religiosity France
religiosity Germany
religiosity India
religiosity Ireland
religiosity Israel
religiosity Italy
religiosity Japan
religiosity Lithuania
religiosity Morocco
religiosity Netherlands
religiosity Romania
religiosity Singapore
religiosity Spain
religiosity Turkey
religiosity UK
religiosity US
Intercept Australia
Intercept Belgium
Intercept Brazil
Intercept Canada
Intercept Chile
Intercept China
Intercept Croatia
Intercept Denmark
Intercept France
Intercept Germany
Intercept India
Intercept Ireland
Intercept Israel
Intercept Italy
Intercept Japan
Intercept Lithuania
Intercept Morocco
Intercept Netherlands
Intercept Romania
Intercept Singapore
Intercept Spain
Intercept Turkey
Intercept UK
Intercept US
−0.75
−0.50
−0.25
0.00
0.25
Estimate

Hypothesis 2: does the association between religiosity and well-being depend on cultural norms of religion?

```
m02 <- brm(data = dat, family = gaussian(),
          formula = wb_overall_mean ~ 1 + age + gender + ses + education + rel_mean +
            cnorm_mean + gdp_scaled + (1 + rel_mean | country),
          prior = c(prior(normal(0, 10), class = Intercept),
                    prior(normal(0, 1), class = b),
                    prior(cauchy(0, 2), class = sd),
                    prior(cauchy(0, 10), class = sigma),
                    prior(lkj(4), class = cor)),
          save_pars = save_pars(all = TRUE),
          iter = iterations, warmup = warmup, chains = chains, cores = 4, seed = 2021)

m2 <- brm(data = dat, family = gaussian(),
          formula = wb_overall_mean ~ 1 + age + gender + ses + education + rel_mean +
            cnorm_mean + gdp_scaled + rel_mean:cnorm_mean + (1 + rel_mean | country),
          prior = c(prior(normal(0, 10), class = Intercept),
                    prior(normal(0, 1), class = b),
                    prior(cauchy(0, 2), class = sd),
                    prior(cauchy(0, 10), class = sigma),
                    prior(lkj(4), class = cor)),
          save_pars = save_pars(all = TRUE),
          iter = iterations, warmup = warmup, chains = chains, cores = 4, seed = 2021)
```

```
print(summary(m2), digits=3)
```

```
##  Family: gaussian
##   Links: mu = identity; sigma = identity
## Formula: wb_overall_mean ~ 1 + age + gender + ses + education + rel_mean + cnorm_mean + gdp_scaled +
##    Data: dat (Number of observations: 10170)
##   Draws: 4 chains, each with iter = 20000; warmup = 5000; thin = 1;
##          total post-warmup draws = 60000
##
## Group-Level Effects:
## ~country (Number of levels: 24)
##                          Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS
## sd(Intercept)               0.215     0.036    0.157    0.298 1.000    18737
## sd(rel_mean)                0.027     0.015    0.002    0.060 1.000    21156
## cor(Intercept,rel_mean)    -0.304     0.290   -0.777    0.342 1.000    66232
##                          Tail_ESS
## sd(Intercept)               30996
## sd(rel_mean)                24686
## cor(Intercept,rel_mean)     40598
##
## Population-Level Effects:
##                      Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS
## Intercept              -0.015     0.047   -0.109    0.077 1.000    12729
## age                     0.023     0.008    0.007    0.038 1.000    97031
## genderother            -0.515     0.115   -0.741   -0.290 1.000   121025
## genderwoman            -0.048     0.019   -0.084   -0.011 1.000   113772
## ses                     0.364     0.010    0.345    0.383 1.000   103102
## education               0.066     0.009    0.048    0.085 1.000   107196
## rel_mean                0.096     0.012    0.073    0.121 1.000    63038
```

```
## cnorm_mean             0.028     0.011    0.006    0.050 1.000   100832
## gdp_scaled             0.061     0.045   -0.029    0.152 1.000    15050
## rel_mean:cnorm_mean    0.040     0.009    0.021    0.058 1.000    81934
##                     Tail_ESS
## Intercept              23477
## age                    45992
## genderother            44226
## genderwoman            43752
## ses                    47907
## education              45461
## rel_mean               44843
## cnorm_mean             44068
## gdp_scaled             24510
## rel_mean:cnorm_mean    47012
##
## Family Specific Parameters:
##       Estimate Est.Error l-95% CI u-95% CI  Rhat Bulk_ESS Tail_ESS
## sigma    0.872     0.006    0.861    0.885 1.000   122254    41509
##
## Draws were sampled using sampling(NUTS). For each parameter, Bulk_ESS
## and Tail_ESS are effective sample size measures, and Rhat is the potential
## scale reduction factor on split chains (at convergence, Rhat = 1).
```

```
# coefficients for the religiosity predictor
summary(m2)$fixed['rel_mean:cnorm_mean',]
```

```
##                       Estimate   Est.Error  l-95% CI   u-95% CI    Rhat
## rel_mean:cnorm_mean 0.03963572 0.009447914 0.0210454 0.05822441 1.00006
##                     Bulk_ESS Tail_ESS
## rel_mean:cnorm_mean 81933.98 47011.59
```

```
# Bayes factor for the inclusion of religiosity as a varying effect
bf20 <- bayes_factor(m2,m02)
```

```
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
```

```
bf20
```

```
## Estimated Bayes factor in favor of m2 over m02: 46.48473
```

```
# Posterior model probability
pp20 <- post_prob(m2,m02)
```

```
## Iteration: 1
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 1
```

```
## Iteration: 2
## Iteration: 3
## Iteration: 4
## Iteration: 5
```

```
pp20
```

```
##         m2        m02
## 0.97848162 0.02151838
```

For research question 2, we find strong evidence that the association between religiosity and well-being depends on the cultural norms of religion within a country: $\text{BF}_{10} = 46.48$, posterior model probability is 0.98 for $\mathcal{M}_2$ and 0.02 for the corresponding $\mathcal{M}_0$, the standardized estimate (beta) of the religiosity-by-cultural norms interaction effect is 0.040, 95% credible interval [0.021, 0.058].