Supplemental Appendix: Introducing Multilevel Meta-analysis to Experimental Political Science: An Application to Personality and Prosocial Behavior

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1 Summary of the Data

First we present a summary of the variables in our three datasets:

```r
library(rjags)

## Loading required package: coda
## Linked to JAGS 3.4.0
## Loaded modules: basemod, bugs

library(foreign)

## clear workspace
rm(list = ls())

## Set working directory
setwd("/Users/Reuben/Documents/Projects_current/Personality_meta-analysis/Data/Bayesian-replication-files")

## load data data for all studies with personality
## data big5/ HEXACO (12 studies)
dl <- read.dta("12-studies_master_benner-fixed.dta")
dl$study <- as.numeric(as.factor(dl$study))
df <- with(dl, data.frame(svo = svo, extro = extro,
                           open = open, agree = agree, conscient = conscient,
                           neuro = neuro, payment = payment, hilbig = hilbig,
                           benner = benner, mbti = mbti, coop = coop, tg = tg,
                           study = study))
dl$n <- nrow(df)

## data for big5/ HEXACO studies only (10 studies)
dl2 <- read.dta("10-studies_master_benner-fixed.dta")
dl2$study <- as.numeric(as.factor(dl2$study))
df2 <- with(dl2, data.frame(svo = svo, extro = extro,
                             open = open, agree = agree, conscient = conscient,
                             neuro = neuro, payment = payment, hilbig = hilbig,
                             benner = benner, mbti = mbti, coop = coop, tg = tg,
                             study = study))
dl2$n <- nrow(df2)

## data for all of our studies, for
## incentivization-only analysis (15 studies)
dl3 <- read.dta("15-studies_master_benner-fixed.dta")
dl3$study <- as.numeric(as.factor(dl3$study))
df3 <- with(dl3, data.frame(svo = svo, extro = extro,
                            open = open, agree = agree, conscient = conscient,
                            neuro = neuro, payment = payment, hilbig = hilbig,
                            benner = benner, mbti = mbti, coop = coop, tg = tg,
                            study = study))
dl3$n <- nrow(df3)

## Summary of dataset For Model 1
summary(df)
```
## s
### svo
#### Min. : 0.0000
#### 1st Qu.: 0.2000
#### Median : 0.4960
#### Mean : 0.4797
#### 3rd Qu.: 0.7000
#### Max. : 1.0500
### extro
#### Min. : 0.0000
#### 1st Qu.: 0.4844
#### Median : 0.6406
#### Mean : 0.5969
#### 3rd Qu.: 0.7500
#### Max. : 1.0000
### open
#### Min. : 0.0000
#### 1st Qu.: 0.4844
#### Median : 0.6458
#### Mean : 0.5967
#### 3rd Qu.: 0.7500
#### Max. : 1.0000
### agree
#### Min. : 0.0000
#### 1st Qu.: 0.3594
#### Median : 0.5200
#### Mean : 0.5167
#### 3rd Qu.: 0.6800
#### Max. : 1.0000

## c
### consci
#### Min. : 0.000
#### 1st Qu.: 0.500
#### Median : 0.625
#### Mean : 0.596
#### 3rd Qu.: 0.750
#### Max. : 1.000
### en
#### Min. : 0.000
#### 1st Qu.: 0.4125
#### Median : 0.6406
#### Mean : 0.5228
#### 3rd Qu.: 0.6406
#### Max. : 1.000
### ne
#### Min. : 0.000
#### 1st Qu.: 0.5208
#### Median : 0.6400
#### Mean : 0.5208
#### 3rd Qu.: 0.6458
#### Max. : 1.000
### payment
#### Min. : 0.000
#### 1st Qu.: 0.6458
#### Median : 0.6458
#### Mean : 0.6458
#### 3rd Qu.: 0.6800
#### Max. : 1.000
### hilbig
#### Min. : 0.000
#### 1st Qu.: 0.3594
#### Median : 0.5200
#### Mean : 0.5167
#### 3rd Qu.: 0.6800
#### Max. : 1.000

## b
### benner
#### Min. : 0.0000
#### 1st Qu.: 0.0000
#### Median : 0.0000
#### Mean : 0.2026
#### 3rd Qu.: 0.0000
#### Max. : 1.0000
### mbti
#### Min. : 0.0000
#### 1st Qu.: 0.0000
#### Median : 0.0000
#### Mean : 0.2253
#### 3rd Qu.: 0.0000
#### Max. : 1.0000
### coop
#### Min. : 0.0000
#### 1st Qu.: 0.0000
#### Median : 0.0000
#### Mean : 0.3047
#### 3rd Qu.: 0.0000
#### Max. : 1.0000
### tg
#### Min. : 0.0000
#### 1st Qu.: 0.0000
#### Median : 0.0000
#### Mean : 0.0367
#### 3rd Qu.: 0.0000
#### Max. : 1.0000

## s
### study
#### Min. : 1.000
#### 1st Qu.: 3.000
#### Median : 5.000
#### Mean : 5.501
#### 3rd Qu.: 7.000
#### Max. : 12.000

## F
### For Model 2
### summary(df2)
## 1st Qu.:0.5312 1st Qu.:0.4125 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.6250 Median :0.5312 Median :0.0000 Median :1.0000
## Mean :0.6170 Mean :0.5228 Mean :0.2670 Mean :0.5497
## 3rd Qu.:0.7188 3rd Qu.:0.6406 3rd Qu.:1.0000 3rd Qu.:1.0000
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.0000
##
## benner mbti coop tg study
## Min. :0.0000 Min. :0 Min. :0.0000 Min. :0 Min. :1.0000
## 1st Qu.:0.0000 1st Qu.:0 1st Qu.:0.0000 1st Qu.:0 1st Qu.:3.0000
## Median :0.0000 Median :0 Median :0.0000 Median :0 Median :4.0000
## Mean :0.2615 Mean :0 Mean :0.3690 Mean :0 Mean :4.6740
## 3rd Qu.:1.0000 3rd Qu.:0 3rd Qu.:1.0000 3rd Qu.:0 3rd Qu.:6.0000
## Max. :1.0000 Max. :0 Max. :1.0000 Max. :0 Max. :10.0000
##
## For Model 3
## summary(df3)
##
## svo extro open agree
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.2000 1st Qu.:0.4844 1st Qu.:0.5000 1st Qu.:0.3594
## Median :0.4667 Median :0.6406 Median :0.6458 Median :0.5200
## Mean :0.4685 Mean :0.5969 Mean :0.5967 Mean :0.5167
## 3rd Qu.:0.6850 3rd Qu.:0.7500 3rd Qu.:0.7500 3rd Qu.:0.6800
## Max. :1.0500 Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :247 NA's :247 NA's :247
##
## conscien neuro payment hilbig
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.5000 1st Qu.:0.4125 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.4685 Median :0.5969 Median :0.5967 Median :0.5167
## Mean :0.4685 Mean :0.5969 Mean :0.5967 Mean :0.5167
## 3rd Qu.:0.7500 3rd Qu.:0.6406 3rd Qu.:1.0000 3rd Qu.:1.0000
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.0000
## NA's :247 NA's :823
##
## benner mbti coop tg
## Min. :0.0000 Min. :0.0000 Min. :0.0000 Min. :0.0000
## 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000 1st Qu.:0.0000
## Median :0.0000 Median :0.0000 Median :0.0000 Median :0.0000
## Mean :0.1847 Mean :0.2054 Mean :0.3006 Mean :0.05742
## 3rd Qu.:0.1847 3rd Qu.:0.2054 3rd Qu.:0.3006 3rd Qu.:0.05742
## Max. :1.0000 Max. :1.0000 Max. :1.0000 Max. :1.0000
##
## study
## Min. :1.000
## 1st Qu.:4.000
## Median :6.000
## Mean :6.633
2  Replication with Frequentist Models

Here we replicate the results in table 3 with the more standard frequentist approach to multilevel modeling. Here we report 95% confidence intervals to be consistent with the presentation in table 3. At the individual level (level 1), the point estimates and even the standard errors for the personality traits are essentially unchanged—in sum, openness and agreeableness are still associated with significantly increased prosocial behavior, whereas the other three personality traits are not. At level 2 however, as $\ldots$, both the point estimates and the standard errors exhibit more variability between the two methods. In general, and as to be expected, the standard errors for the level 2 variables are much smaller here than in the Bayesian analysis reported in the text. As a result, in both models 1 and 2, the estimates for Hilbig and Payment are different from zero. However, these standard errors are too small, and therefore the Bayesian estimates are more credible. These models were estimated using the `xtmixed` command in Stata.

3  Additional Information on Bayesian Models

For all three models, the BUGS model was specified as follows:

```
model{
  # individual-level equation
  for (i in 1:n){
    svo[i] ~ dnorm(svo.hat[i], tau.svo)
    svo.hat[i] <- beta0[study[i]] + inprod(beta[],X[i,])
  }
  # priors for individual-level parameters
  tau.svo <- pow(sigma.svo, -2)
  sigma.svo ~ dunif(0, 100)
  for(b in 1:nX){
    beta[b] ~ dnorm(0,.001)
  }
  # study-level equation
  for (j in 1:m){
    beta0[j] ~ dnorm(beta0.hat[j], tau.beta0)
    beta0.hat[j] <- inprod(gamma[],Z[j,])
  }
  # priors for study-level parameters
  tau.beta0 <- pow(sigma.beta0, -2)
```

# Table 1: Prosociality, Personality and Incentivization: Multilevel Regression Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1: Big Five &amp; MBTI Studies</th>
<th>Model 2: Big Five Studies</th>
<th>Model 3: Incentivization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subject-level variables</strong></td>
<td>Mean (95% Conf. Interval)</td>
<td>Mean (95% Conf. Interval)</td>
<td>Mean (95% Conf. Interval)</td>
</tr>
<tr>
<td>Extroversion</td>
<td>0.01 [-0.06, 0.075]</td>
<td>-0.06 [-0.15, 0.03]</td>
<td>-</td>
</tr>
<tr>
<td>Openness</td>
<td>0.09 [0.03, 0.16]</td>
<td>0.23 [0.13, 0.33]</td>
<td>-</td>
</tr>
<tr>
<td>Agreeableness</td>
<td>0.10 [0.03, 0.17]</td>
<td>0.16 [0.06, 0.26]</td>
<td>-</td>
</tr>
<tr>
<td>Conscientiousness</td>
<td>-0.03 [-0.10, 0.03]</td>
<td>-0.07 [-0.17, 0.02]</td>
<td>-</td>
</tr>
<tr>
<td>Neuroticism</td>
<td>-</td>
<td>-0.06 [-0.15, 0.03]</td>
<td>-</td>
</tr>
<tr>
<td><strong>Study-level variables</strong></td>
<td>Mean (95% Conf. Interval)</td>
<td>Mean (95% Conf. Interval)</td>
<td>Mean (95% Conf. Interval)</td>
</tr>
<tr>
<td>(Global) Intercept</td>
<td>0.26 [0.10, 0.42]</td>
<td>0.16 [-0.06, 0.37]</td>
<td>0.43 [0.31, 0.55]</td>
</tr>
<tr>
<td>Payment</td>
<td>0.15 [0.01, 0.29]</td>
<td>0.18 [0.03, 0.32]</td>
<td>0.03 [-0.12, 0.18]</td>
</tr>
<tr>
<td>Author: Hilbig</td>
<td>0.19 [0.03, 0.36]</td>
<td>0.25 [0.07, 0.43]</td>
<td>-</td>
</tr>
<tr>
<td>Author: Ben-Ner</td>
<td>-0.15 [-0.32, 0.02]</td>
<td>-0.09 [-0.29, 0.11]</td>
<td>-</td>
</tr>
<tr>
<td>MBTI Personality Measure</td>
<td>0.10 [-0.07, 0.27]</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cooperative</td>
<td>-0.06 [-0.14, 0.02]</td>
<td>0.03 [-0.13, 0.18]</td>
<td>-0.06 [-0.14, 0.02]</td>
</tr>
</tbody>
</table>

# Observations:
- Model 1: 2,557
- Model 2: 1,981
- Model 3: 2,804

# Studies:
- Model 1: 12
- Model 2: 10
- Model 3: 15
sigma.beta0 ~ dunif(0, 100)
for (g in 1:nZ){
    gamma[g] ~ dnorm(0, .001)
}

Below is the R code, for the estimation of models 1, 2 and 3, in the text, for which we used the rjags package.

We also present the “trace plots” for each estimation. These figures plot the value of the estimated parameter over each of the 5,000 iterations in our simulation. The plots plot iterations from 1,000 to 6,000 because the first 1,000 iterations are the “adaptation period. The numbering of the parameters follows the order they are entered in the models above, with the “betas” representing the level 1 coefficients in the order that they enter the models above, and the “gammas” representing the level 2 coefficients in the order that they enter the models above.

## Model 1

```r
m1dl <- with(df, list(svo = svo, study = study, n = length(svo),
  m = length(unique(study)), X = cbind(extro, open,
    agree, conscient), nX = 4, Z = aggregate(cbind(1,
    payment, hilbig, benner, mbti, coop), by = list(study = study),
    FUN = mean)[, -1], nZ = 6))

m1jmod <- jags.model("mlma.bugs", data = m1dl, n.chains = 4,
  quiet = TRUE)

m1jags <- coda.samples(model = m1jmod, n.iter = 5000,
  thin = 5, progress.bar = "none", variable.names = c("beta",
  "gamma"))
```

```r
par(mfrow = c(1,2))
coda::traceplot(m1jags)
```

![Trace of beta[1]](image1)

![Trace of beta[2]](image2)
## Model 2

```r
m2dl <- with(na.omit(df2), list(svo = svo, study = as.numeric(as.factor(study))),
           n = length(svo), m = length(unique(study)), X = cbind(extro,
           open, agree, conscien, neuro), nX = 5, Z = aggregate(cbind(1,
           payment, hilbig, benner, coop), by = list(study = study),
           FUN = mean)[, -1], nZ = 5))
m2jmod <- jags.model("mlma.bugs", data = m2dl, n.chains = 4,
                      quiet = TRUE)
m2jags <- coda.samples(model = m2jmod, n.iter = 5000,
                      thin = 5, progress.bar = "none", variable.names = c("beta",
                      "gamma"))
```

```r
par(mfrow = c(1,2))
coda::traceplot(m2jags)
```
## Model 3

```r
m3dl <- with(df3, list(svo = svo, study = study, n = length(svo), 
  m = length(unique(study)), X = as.matrix(rep(0, 
    length(svo))), nX = 1, Z = aggregate(cbind(1, 
    payment, coop), by = list(study = study), FUN = mean)[, 
    -1], nZ = 3))

m3jmod <- jags.model("mlma.bugs", data = m3dl, n.chains = 4,
  quiet = TRUE)

m3jags <- coda.samples(model = m3jmod, n.iter = 5000,
  thin = 5, progress.bar = "none", variable.names = c("gamma"))
```

```
par(mfrow = c(1,2))
coda::traceplot(m3jags)
```
As expected, in most all of the cases in all three models, the variability is higher for the \( \gamma \)-parameters (level 2) than for the \( \beta \) parameters (level 1).