German and Dutch Translations of the Artificial-Social-Agent Questionnaire Instrument for Evaluating Human-Agent Interactions

Cultural Comparison - Pairwise Comparisons

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Introduction

This document presents a comparison of human-ASA interaction evaluations between different cultural backgrounds, i.e., a mixed international English-speaking group, a bilingual group with Dutch as first and primary language and with English as fluent language, and a bilingual group with German as primary language and English as fluent language.

Specifically, we here look at pairwise comparisons between cultural backgrounds.

Required files: data_culture_DE_EN_NL.sav.

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Load packages

Let's load the packages that we need.

```
library(dplyr)  # Use select function
library(foreign)  # Open various data files
library(formatR)  # For formatting
library(haven)  # Use read_sav fuction
library(knitr)  # Get markdown file
library(pander)  # For pandering tables
library(rethinking)  # Run ulam
```

```
panderOptions("table.alignment.default", "left")
panderOptions("round", 2)
```

Define constants

And let's define a few constants that we use throughout.

```
NUM_DIM = 24

NUM_ITERATIONS_PAIRWISE_COMP = 7000
NUM_CHAINS = 4
NUM_SAMPLES_POST = 1e4

GERMAN_INDEX = 1
ENGLISH_INDEX = 2
DUTCH_INDEX = 3
```

Load data

```
data_culture <- data.frame(read_sav("data_culture_DE_EN_NL.sav"))
# So that culture starts at 1 and not at 0
data_culture$Culture <- data_culture$Culture + 1
```

Comparison of Human-ASA Interaction between Different Cultural Backgrounds

Here we compare the human-ASA interaction evaluations by our different cultural backgrounds. Two-level linear regression models were implemented to explore construct and dimension score differences between the sample groups, with agent as random intercept to control for the dependency on agent assignment. For the Bayesian analysis we used the rethinking package developed by Richard McElreath.

English vs. Dutch

Now we perform a pairwise comparison between our bilingual Dutch and mixed international English sample.

```
# Initialize output list of Construct/dimension differences between two cultural groups
cul_list <- data.frame(ConstructID=double(),mean_Dutch=double(),sd_Dutch=double(),
                       mean_Eng=double(),sd_Eng=double(),mean_diff=double(),
                       sd_diff=double(),lo2_5=double(),
                       hi97_5=double(),n_eff=double(),Rhat4=double(),
                       P_posterior=double(),zero_excl=character())


for(j in 1:NUM_DIM)
# Go step by step through the 24 constructs/dimensions of the ASA questionnaire
{
  # Select scores data for ASAQ construct j
  d_c<-subset(data_culture, ConstructID==j, select=c(AgentID, Culture, Rating))
  # Select only Dutch and English
  d_c <- subset(d_c, Culture %in% c(DUTCH_INDEX, ENGLISH_INDEX))
  # Make culture 0 (English) /1 (Dutch)
```

```r
d_c$Culture = as.numeric(d_c$Culture == DUTCH_INDEX)

set.seed(1)  # For reproducibility

# Define the model we fit on the data. This is a multilevel model,
# with agent as random intercept to control for
# dependency of agent assignment, and culture as fixed effect
m <- ulam(
  alist(
    # Likelihood
    Rating ~ dnorm(mu, sigma),

    # Linear model
    mu <- a + a_Agent[AgentID] + c_cult*Culture,

    # Adaptive prior
    a_Agent[AgentID] ~ dnorm(0, sigma_agent),

    # Hyper prior
    sigma_agent ~ dcauchy(0, 1),

    # Fixed priors
    a ~ dnorm(0, 2),
    c_cult ~ dnorm(0, 1),
    sigma ~ dcauchy(0, 1)
  ), data = d_c, iter = NUM_ITERATIONS_PAIRWISE_COMP, chains = NUM_CHAINS, cores = 4, log_lik = TRUE,
  control=list(adapt_delta=.99)
)


## Calculate posterior probability
# Extract samples from the posterior distribution
post_samples <- extract.samples(m, NUM_SAMPLES_POST)

# Select samples with positive posterior values (positive bias)
c_cult <- as.numeric(post_samples$c_cult)
H0_post <- subset(c_cult, c_cult>0)

# Calculate probability of a positive bias
H0_post_p <- length(H0_post)/NUM_SAMPLES_POST
# Probability of a negative bias
H1_post_p <- 1 - H0_post_p

# Subset of only Dutch sample
d_c_Dutch <- subset(d_c, Culture == 1)

# Subset of only mixed international sample
d_c_Eng <- subset(d_c, Culture == 0)

# Line 17 in the precis output, are the results related to c_cult coefficient
o <- precis(m,  depth=2, prob=.95)
l <- data.frame(ConstructID = j,
                mean_Dutch = mean(d_c_Dutch$Rating),
```

```
                  sd_Dutch = sd(d_c_Dutch$Rating),
                  mean_Eng = mean(d_c_Eng$Rating),
                  sd_Eng = sd(d_c_Eng$Rating),
                  mean_diff = as.numeric(o$mean[17]),
                  sd_diff = as.numeric(o$sd[17]),
                  lo2_5 = as.numeric(o$`2.5%`[17]),
                  hi97_5 = as.numeric(o$`97.5%`[17]),
                  n_eff = as.numeric(o$n_eff[17]),
                  Rhat4 = as.numeric(o$Rhat4[17]),
                  P_posterior = max(H0_post_p,H1_post_p),
                  zero_excl = ifelse((as.numeric(o$`2.5%`[17])>0)
                                | (as.numeric(o$`97.5%`[17])<0),
                                '*','')
                  )

  # Store results in a list to print later on
  cul_list <- rbind(cul_list, l)

}
```

The last step is to print the results of the model analysis.

```
## Print results Add construct/dimension name code
cul_list$Construct = c("HLA", "HLB", "NA", "NB", "AAS", "AU",
    "PF", "AL", "AS", "APP", "UAA", "AE", "UE", "UT", "UAL",
    "AA", "AC", "AI", "AT", "SP", "IIS", "AEI", "UEP", "UAI")
pander(select(cul_list, ConstructID, mean_Dutch, sd_Dutch, mean_Eng,
    sd_Eng, Construct), caption = "Construct/dimension differences between bilingual Dutch and mixed in
```

Table 1: Construct/dimension differences between bilingual Dutch and mixed international English (Part 1)

ConstructID	mean_Dutch	sd_Dutch	mean_Eng	sd_Eng	Construct
1	-1.44	1.76	-0.75	2.01	HLA
2	-0.9	1.52	0.04	1.6	HLB
3	-1.01	1.51	-0.24	1.49	NA
4	-0.91	1.55	-0.29	1.55	NB
5	1.24	1.27	1.35	1.22	AAS
6	1.29	1.21	1.23	1.19	AU
7	1.22	1.18	1.31	1.12	PF
8	0.29	1.34	0.77	1.4	AL
9	-0.04	1.43	0.32	1.49	AS
10	-0.38	1.55	0.2	1.49	APP
11	0.95	1.3	1.31	1.18	UAA
12	0.81	1.32	1.25	1.23	AE
13	1.95	0.82	1.81	1.01	UE
14	0.26	1.15	0.43	1.21	UT
15	0.29	1.14	0.51	1.15	UAL
16	1.68	1.14	1.65	1.16	AA
17	1.61	1.08	1.55	1.07	AC
18	0.65	1.38	0.69	1.35	AI
19	1.28	1.36	1.43	1.33	AT
20	-0.47	1.45	-0.16	1.51	SP
21	0.19	1.08	0.65	1.14	IIS

ConstructID	mean_Dutch	sd_Dutch	mean_Eng	sd_Eng	Construct
22	-0.96	1.78	-0.67	1.7	AEI
23	0.87	1.25	0.62	1.29	UEP
24	0.99	1.07	0.79	1.2	UAI

```
pander(select(cul_list, ConstructID, mean_diff, sd_diff, lo2_5,
    hi97_5, Construct), caption = "Construct/dimension differences between bilingual Dutch and mixed in
```

Table 2: Construct/dimension differences between bilingual Dutch and mixed international English (Part 2)

ConstructID	mean_diff	sd_diff	lo2_5	hi97_5	Construct
1	-0.68	0.13	-0.93	-0.43	HLA
2	-0.94	0.14	-1.21	-0.66	HLB
3	-0.74	0.12	-0.99	-0.51	NA
4	-0.6	0.13	-0.85	-0.35	NB
5	-0.1	0.12	-0.33	0.13	AAS
6	0.05	0.11	-0.16	0.27	AU
7	-0.09	0.11	-0.3	0.13	PF
8	-0.46	0.12	-0.69	-0.23	AL
9	-0.33	0.13	-0.59	-0.08	AS
10	-0.56	0.13	-0.82	-0.31	APP
11	-0.35	0.11	-0.57	-0.13	UAA
12	-0.43	0.11	-0.64	-0.21	AE
13	0.13	0.09	-0.05	0.31	UE
14	-0.18	0.11	-0.39	0.04	UT
15	-0.23	0.11	-0.45	-0.02	UAL
16	0.03	0.11	-0.19	0.25	AA
17	0.06	0.1	-0.15	0.27	AC
18	-0.06	0.12	-0.29	0.18	AI
19	-0.16	0.11	-0.38	0.06	AT
20	-0.32	0.14	-0.59	-0.05	SP
21	-0.47	0.11	-0.68	-0.26	IIS
22	-0.31	0.14	-0.59	-0.03	AEI
23	0.23	0.11	0.01	0.44	UEP
24	0.19	0.11	-0.03	0.41	UAI

```
pander(select(cul_list, ConstructID, n_eff, Rhat4, P_posterior,
    zero_excl, Construct), caption = "Construct/dimension differences between bilingual Dutch and mixed
```

Table 3: Construct/dimension differences between bilingual Dutch and mixed international English (Part 3)

ConstructID	n_eff	Rhat4	P_posterior	zero_excl	Construct
1	7121	1	1	*	HLA
2	9655	1	1	*	HLB
3	7940	1	1	*	NA
4	8356	1	1	*	NB
5	14947	1	0.8		AAS
6	14085	1	0.68		AU

ConstructID	n_eff	Rhat4	P_posterior	zero_excl	Construct
7	18249	1	0.79		PF
8	13496	1	1	*	AL
9	8261	1	0.99	*	AS
10	9131	1	1	*	APP
11	17150	1	1	*	UAA
12	13161	1	1	*	AE
13	16378	1	0.92		UE
14	13808	1	0.94		UT
15	14388	1	0.98	*	UAL
16	14492	1	0.61		AA
17	15159	1	0.73		AC
18	9046	1	0.69		AI
19	8161	1	0.92		AT
20	12312	1	0.99	*	SP
21	11768	1	1	*	IIS
22	8528	1	0.98	*	AEI
23	8115	1	0.98	*	UEP
24	13507	1	0.96		UAI

```
## Print grand means
Variable <- c("mean_Dutch", "sd_Dutch", "mean_Eng", "sd_Eng",
    "mean_diff", "sd_diff", "minimum_diff", "maximum_diff", "n_zero_excl",
    "percent_zero_excl")
# Calculate grand mean of mean_Dutch, sd_Dutch, mean_Eng,
# sd_Eng sd_diff, grand mean of the absolute value of mean
# differences, number of constructs/dimensions with
# credible bias indication, and percentage of these
# constructs/dimensions
Grand_mean <- c(mean(cul_list$mean_Dutch), mean(cul_list$sd_Dutch),
    mean(cul_list$mean_Eng), mean(cul_list$sd_Eng), mean(abs(cul_list$mean_diff)),
    mean(cul_list$sd_diff), min(cul_list$mean_diff), max(cul_list$mean_diff),
    sum(cul_list$zero_excl == "*"), round(sum(cul_list$zero_excl ==
        "*")/length(cul_list$ConstructID), digits = 4) * 100)
GrandMean <- cbind(Variable, Grand_mean)

pander(GrandMean, caption = "Grand mean of 24 constructs/dimensions between bilingual Dutch and mixed i
```

Table 4: Grand mean of 24 constructs/dimensions between bilingual Dutch and mixed international English

Variable	Grand_mean
mean_Dutch	0.393732638888889
sd_Dutch	1.31774947186162
mean_Eng	0.658302005012531
sd_Eng	1.33723154741264
mean_diff	0.321220848700698
sd_diff	0.117560148144281
minimum_diff	-0.9357086775
maximum_diff	0.226931358922214
n_zero_excl	14

Variable	Grand_mean
percent_zero_excl	58.33

English vs. German

Now we perform a pairwise comparison between our bilingual German and mixed international English sample.

```
# Initialize output list of Construct/dimension differences between two cultural groups
cul_list <- data.frame(ConstructID=double(),mean_German=double(),sd_German=double(),
                       mean_Eng=double(),sd_Eng=double(),mean_diff=double(),
                       sd_diff=double(),lo2_5=double(),
                       hi97_5=double(),n_eff=double(),Rhat4=double(),
                       P_posterior=double(),zero_excl=character())


for(j in 1:NUM_DIM)
# Go step by step through the 24 constructs/dimensions of the ASA questionnaire
{
  # Select scores data for ASAQ construct j
  d_c<-subset(data_culture, ConstructID==j, select=c(AgentID, Culture, Rating))
  # Select only German and English
  d_c <- subset(d_c, Culture %in% c(GERMAN_INDEX, ENGLISH_INDEX))
  # Make culture 1 (German) /0 (English)
  d_c$Culture = as.numeric(d_c$Culture == GERMAN_INDEX)

  set.seed(1)  # For reproducibility

  # Define the model we fit on the data. This is a multilevel model,
  # with agent as random intercept to control for
  # dependency of agent assignment, and culture as fixed effect
  m <- ulam(
    alist(
      # Likelihood
      Rating ~ dnorm(mu, sigma),

      # Linear model
      mu <- a + a_Agent[AgentID] + c_cult*Culture,

      # Adaptive prior
      a_Agent[AgentID] ~ dnorm(0, sigma_agent),

      # Hyper prior
      sigma_agent ~ dcauchy(0, 1),

      # Fixed priors
      a ~ dnorm(0, 2),
      c_cult ~ dnorm(0, 1),
      sigma ~ dcauchy(0, 1)
    ), data = d_c, iter = NUM_ITERATIONS_PAIRWISE_COMP, chains = NUM_CHAINS, cores = 4, log_lik = TRUE,
    control=list(adapt_delta=.99)
  )
```

```
  ## Calculate posterior probability
  # Extract samples from the posterior distribution
  post_samples <- extract.samples(m, NUM_SAMPLES_POST)

  # Select samples with positive posterior values (positive bias)
  c_cult <- as.numeric(post_samples$c_cult)
  H0_post <- subset(c_cult, c_cult>0)

  # Calculate probability of a positive bias
  H0_post_p <- length(H0_post)/NUM_SAMPLES_POST
  # Probability of a negative bias
  H1_post_p <- 1 - H0_post_p

  # Subset of only German sample
  d_c_German <- subset(d_c, Culture == 1)

  # Subset of only mixed international sample
  d_c_Eng <- subset(d_c, Culture == 0)

  # Line 17 in the precis output, are the results related to c_cul coefficient
  o <- precis(m,  depth=2, prob=.95)
  l <- data.frame(ConstructID = j,
                  mean_German = mean(d_c_German$Rating),
                  sd_German = sd(d_c_German$Rating),
                  mean_Eng = mean(d_c_Eng$Rating),
                  sd_Eng = sd(d_c_Eng$Rating),
                  mean_diff = as.numeric(o$mean[17]),
                  sd_diff = as.numeric(o$sd[17]),
                  lo2_5 = as.numeric(o$`2.5%`[17]),
                  hi97_5 = as.numeric(o$`97.5%`[17]),
                  n_eff = as.numeric(o$n_eff[17]),
                  Rhat4 = as.numeric(o$Rhat4[17]),
                  P_posterior = max(H0_post_p,H1_post_p),
                  zero_excl = ifelse((as.numeric(o$`2.5%`[17])>0)
                                | (as.numeric(o$`97.5%`[17])<0),
                                '*','')
                  )

  # Store results in a list to print later on
  cul_list <- rbind(cul_list, l)

}
```

The last step is to print the results of the model analysis.

```
## Print results Add construct/dimension name code
cul_list$Construct = c("HLA", "HLB", "NA", "NB", "AAS", "AU",
    "PF", "AL", "AS", "APP", "UAA", "AE", "UE", "UT", "UAL",
    "AA", "AC", "AI", "AT", "SP", "IIS", "AEI", "UEP", "UAI")
pander(select(cul_list, ConstructID, mean_German, sd_German,
    mean_Eng, sd_Eng, Construct), caption = "Construct/dimension differences between bilingual German ar
```

Table 5: Construct/dimension differences between bilingual German and mixed international English (Part 1)

ConstructID	mean_German	sd_German	mean_Eng	sd_Eng	Construct
1	-1.17	1.91	-0.75	2.01	HLA
2	-0.34	1.62	0.04	1.6	HLB
3	-0.53	1.55	-0.24	1.49	NA
4	-0.53	1.63	-0.29	1.55	NB
5	1.24	1.22	1.35	1.22	AAS
6	1.49	1.11	1.23	1.19	AU
7	1.25	1.01	1.31	1.12	PF
8	0.66	1.36	0.77	1.4	AL
9	0.32	1.39	0.32	1.49	AS
10	-0.58	1.65	0.2	1.49	APP
11	1.27	1.21	1.31	1.18	UAA
12	1.19	1.21	1.25	1.23	AE
13	1.58	1.12	1.81	1.01	UE
14	0.4	1.14	0.43	1.21	UT
15	0.43	1.05	0.51	1.15	UAL
16	1.84	0.99	1.65	1.16	AA
17	1.72	1.19	1.55	1.07	AC
18	0.57	1.31	0.69	1.35	AI
19	1.3	1.44	1.43	1.33	AT
20	-0.58	1.52	-0.16	1.51	SP
21	0.21	1.37	0.65	1.14	IIS
22	-0.72	1.72	-0.67	1.7	AEI
23	0.73	1.49	0.62	1.29	UEP
24	0.92	1.06	0.79	1.2	UAI

```
pander(select(cul_list, ConstructID, mean_diff, sd_diff, lo2_5,
    hi97_5, Construct), caption = "Construct/dimension differences between bilingual German and mixed i
```

Table 6: Construct/dimension differences between bilingual German and mixed international English (Part 2)

ConstructID	mean_diff	sd_diff	lo2_5	hi97_5	Construct
1	-0.36	0.13	-0.62	-0.11	HLA
2	-0.36	0.14	-0.63	-0.09	HLB
3	-0.27	0.12	-0.51	-0.04	NA
4	-0.21	0.13	-0.46	0.04	NB
5	-0.11	0.11	-0.33	0.12	AAS
6	0.26	0.11	0.05	0.46	AU
7	-0.05	0.11	-0.26	0.15	PF
8	-0.11	0.12	-0.34	0.12	AL
9	0	0.13	-0.25	0.25	AS
10	-0.76	0.13	-1.01	-0.51	APP
11	-0.04	0.11	-0.26	0.17	UAA
12	-0.06	0.11	-0.28	0.15	AE
13	-0.23	0.1	-0.42	-0.04	UE
14	-0.04	0.11	-0.26	0.18	UT
15	-0.09	0.11	-0.3	0.12	UAL
16	0.18	0.11	-0.03	0.4	AA

ConstructID	mean_diff	sd_diff	lo2_5	hi97_5	Construct
17	0.17	0.1	-0.04	0.36	AC
18	-0.12	0.12	-0.35	0.12	AI
19	-0.13	0.11	-0.35	0.09	AT
20	-0.41	0.14	-0.68	-0.13	SP
21	-0.43	0.11	-0.65	-0.21	IIS
22	-0.05	0.14	-0.33	0.22	AEI
23	0.1	0.11	-0.12	0.32	UEP
24	0.12	0.11	-0.09	0.34	UAI

```
pander(select(cul_list, ConstructID, n_eff, Rhat4, P_posterior,
    zero_excl, Construct), caption = "Construct/dimension differences between bilingual German and mixed
```

Table 7: Construct/dimension differences between bilingual German and mixed international English (Part 3)

ConstructID	n_eff	Rhat4	P_posterior	zero_excl	Construct
1	5749	1	1	*	HLA
2	10030	1	1	*	HLB
3	6628	1	0.99	*	NA
4	7933	1	0.95		NB
5	14108	1	0.83		AAS
6	17465	1	0.99	*	AU
7	17165	1	0.69		PF
8	9135	1	0.83		AL
9	10646	1	0.5		AS
10	11122	1	1	*	APP
11	12140	1	0.66		UAA
12	10524	1	0.72		AE
13	16201	1	0.99	*	UE
14	11870	1	0.63		UT
15	17863	1	0.79		UAL
16	16066	1	0.95		AA
17	14676	1	0.95		AC
18	11126	1	0.84		AI
19	8880	1	0.87		AT
20	14830	1	1	*	SP
21	13638	1	1	*	IIS
22	10247	1	0.65		AEI
23	10391	1	0.82		UEP
24	14704	1	0.87		UAI

```
## Print grand means
Variable <- c("mean_German", "sd_German", "mean_Eng", "sd_Eng",
    "mean_diff", "sd_diff", "minimum_diff", "maximum_diff", "n_zero_excl",
    "percent_zero_excl")
# Calculate grand mean of mean_German, sd_German, mean_Eng,
# sd_Eng sd_diff, grand mean of the absolute value of mean
# differences, number of constructs/dimensions with
# credible bias indication, and percentage of these
# constructs/dimensions
```

```
Grand_mean <- c(mean(cul_list$mean_German), mean(cul_list$sd_German),
    mean(cul_list$mean_Eng), mean(cul_list$sd_Eng), mean(abs(cul_list$mean_diff)),
    mean(cul_list$sd_diff), min(cul_list$mean_diff), max(cul_list$mean_diff),
    sum(cul_list$zero_excl == "*"), round(sum(cul_list$zero_excl ==
        "*")/length(cul_list$ConstructID), digits = 4) * 100)
GrandMean <- cbind(Variable, Grand_mean)

pander(GrandMean, caption = "Grand mean of 24 constructs/dimensions between bilingual German and mixed
```

Table 8: Grand mean of 24 constructs/dimensions between bilingual German and mixed international English

Variable	Grand_mean
mean_German	0.5290625
sd_German	1.34375067260242
mean_Eng	0.658302005012531
sd_Eng	1.33723154741264
mean_diff	0.194310040197125
sd_diff	0.117732748873944
minimum_diff	-0.762116270571429
maximum_diff	0.255170592388757
n_zero_excl	8
percent_zero_excl	33.33

German vs. Dutch

Now we perform a pairwise comparison between our bilingual German and bilingual Dutch sample.

```
# Initialize output list of Construct/dimension differences between two cultural groups
cul_list <- data.frame(ConstructID=double(),mean_German=double(),sd_German=double(),
                       mean_Dutch=double(),sd_Dutch=double(),mean_diff=double(),
                       sd_diff=double(),lo2_5=double(),
                       hi97_5=double(),n_eff=double(),Rhat4=double(),
                       P_posterior=double(),zero_excl=character())


for(j in 1:NUM_DIM)
# Go step by step through the 24 constructs/dimensions of the ASA questionnaire
{
  # Select scores data for ASAQ construct j
  d_c<-subset(data_culture, ConstructID==j, select=c(AgentID, Culture, Rating))
  # Select only Dutch and German
  d_c <- subset(d_c, Culture %in% c(GERMAN_INDEX, DUTCH_INDEX))
  # Make culture 0 (Dutch) /1 (German)
  d_c$Culture = as.numeric(d_c$Culture == GERMAN_INDEX)

  set.seed(1)  # For reproducibility

  # Define the model we fit on the data. This is a multilevel model,
  # with agent as random intercept to control for
  # dependency of agent assignment, and culture as fixed effect
  m <- ulam(
    alist(
```

```
    # Likelihood
    Rating ~ dnorm(mu, sigma),

    # Linear model
    mu <- a + a_Agent[AgentID] + c_cult*Culture,

    # Adaptive prior
    a_Agent[AgentID] ~ dnorm(0, sigma_agent),

    # Hyper prior
    sigma_agent ~ dcauchy(0, 1),

    # Fixed priors
    a ~ dnorm(0, 2),
    c_cult ~ dnorm(0, 1),
    sigma ~ dcauchy(0, 1)
  ), data = d_c, iter = NUM_ITERATIONS_PAIRWISE_COMP, chains = NUM_CHAINS, cores = 4, log_lik = TRUE,
  control=list(adapt_delta=.99)
)


## Calculate posterior probability
# Extract samples from the posterior distribution
post_samples <- extract.samples(m, NUM_SAMPLES_POST)

# Select samples with positive posterior values (positive bias)
c_cult <- as.numeric(post_samples$c_cult)
H0_post <- subset(c_cult, c_cult>0)

# Calculate probability of a positive bias
H0_post_p <- length(H0_post)/NUM_SAMPLES_POST
# Probability of a negative bias
H1_post_p <- 1 - H0_post_p

# Subset of only German sample
d_c_German <- subset(d_c, Culture == 1)

# Subset of only Dutch sample
d_c_Dutch <- subset(d_c, Culture == 0)

# Line 17 in the precis output, are the results related to c_cul coefficient
o <- precis(m,  depth=2, prob=.95)
l <- data.frame(ConstructID = j,
                mean_Dutch = mean(d_c_Dutch$Rating),
                sd_Dutch = sd(d_c_Dutch$Rating),
                mean_German = mean(d_c_German$Rating),
                sd_German = sd(d_c_German$Rating),
                mean_diff = as.numeric(o$mean[17]),
                sd_diff = as.numeric(o$sd[17]),
                lo2_5 = as.numeric(o$`2.5%`[17]),
                hi97_5 = as.numeric(o$`97.5%`[17]),
                n_eff = as.numeric(o$n_eff[17]),
                Rhat4 = as.numeric(o$Rhat4[17]),
```

```
                  P_posterior = max(H0_post_p,H1_post_p),
                  zero_excl = ifelse((as.numeric(o$`2.5%`[17])>0)
                              | (as.numeric(o$`97.5%`[17])<0),
                              '*','')
                  )

  # Store results in a list to print later on
  cul_list <- rbind(cul_list, l)

}
```

The last step is to print the results of the model analysis.

```
## Print results Add construct/dimension name code
cul_list$Construct = c("HLA", "HLB", "NA", "NB", "AAS", "AU",
    "PF", "AL", "AS", "APP", "UAA", "AE", "UE", "UT", "UAL",
    "AA", "AC", "AI", "AT", "SP", "IIS", "AEI", "UEP", "UAI")
pander(select(cul_list, ConstructID, mean_German, sd_German,
    mean_Dutch, sd_Dutch, Construct), caption = "Construct/dimension differences between bilingual Germa
```

Table 9: Construct/dimension differences between bilingual German and bilingual Dutch (Part 1)

ConstructID	mean_German	sd_German	mean_Dutch	sd_Dutch	Construct
1	-1.17	1.91	-1.44	1.76	HLA
2	-0.34	1.62	-0.9	1.52	HLB
3	-0.53	1.55	-1.01	1.51	NA
4	-0.53	1.63	-0.91	1.55	NB
5	1.24	1.22	1.24	1.27	AAS
6	1.49	1.11	1.29	1.21	AU
7	1.25	1.01	1.22	1.18	PF
8	0.66	1.36	0.29	1.34	AL
9	0.32	1.39	-0.04	1.43	AS
10	-0.58	1.65	-0.38	1.55	APP
11	1.27	1.21	0.95	1.3	UAA
12	1.19	1.21	0.81	1.32	AE
13	1.58	1.12	1.95	0.82	UE
14	0.4	1.14	0.26	1.15	UT
15	0.43	1.05	0.29	1.14	UAL
16	1.84	0.99	1.68	1.14	AA
17	1.72	1.19	1.61	1.08	AC
18	0.57	1.31	0.65	1.38	AI
19	1.3	1.44	1.28	1.36	AT
20	-0.58	1.52	-0.47	1.45	SP
21	0.21	1.37	0.19	1.08	IIS
22	-0.72	1.72	-0.96	1.78	AEI
23	0.73	1.49	0.87	1.25	UEP
24	0.92	1.06	0.99	1.07	UAI

```
pander(select(cul_list, ConstructID, mean_diff, sd_diff, lo2_5,
    hi97_5, Construct), caption = "Construct/dimension differences between bilingual German and bilingua
```

Table 10: Construct/dimension differences between bilingual German and bilingual Dutch (Part 2)

ConstructID	mean_diff	sd_diff	lo2_5	hi97_5	Construct
1	0.31	0.16	0	0.62	HLA
2	0.58	0.17	0.25	0.91	HLB
3	0.46	0.14	0.19	0.74	NA
4	0.39	0.15	0.1	0.68	NB
5	0.01	0.14	-0.28	0.29	AAS
6	0.19	0.13	-0.07	0.46	AU
7	0.04	0.13	-0.23	0.3	PF
8	0.36	0.14	0.09	0.63	AL
9	0.34	0.15	0.06	0.63	AS
10	-0.17	0.16	-0.48	0.15	APP
11	0.31	0.14	0.03	0.58	UAA
12	0.37	0.14	0.1	0.63	AE
13	-0.36	0.12	-0.59	-0.13	UE
14	0.14	0.14	-0.14	0.4	UT
15	0.14	0.14	-0.13	0.41	UAL
16	0.15	0.13	-0.11	0.41	AA
17	0.11	0.13	-0.15	0.38	AC
18	-0.08	0.16	-0.39	0.23	AI
19	0.03	0.13	-0.22	0.28	AT
20	-0.11	0.17	-0.44	0.21	SP
21	0.04	0.14	-0.23	0.32	IIS
22	0.24	0.17	-0.09	0.57	AEI
23	-0.11	0.14	-0.38	0.17	UEP
24	-0.06	0.12	-0.3	0.18	UAI

```
pander(select(cul_list, ConstructID, n_eff, Rhat4, P_posterior,
    zero_excl, Construct), caption = "Construct/dimension differences between bilingual German and bili
```

Table 11: Construct/dimension differences between bilingual German and bilingual Dutch (Part 3)

ConstructID	n_eff	Rhat4	P_posterior	zero_excl	Construct
1	9388	1	0.97		HLA
2	17284	1	1	*	HLB
3	8276	1	1	*	NA
4	10231	1	1	*	NB
5	13981	1	0.52		AAS
6	13408	1	0.92		AU
7	15176	1	0.61		PF
8	8878	1	0.99	*	AL
9	10923	1	0.99	*	AS
10	9525	1	0.85		APP
11	15363	1	0.98	*	UAA
12	11758	1	1	*	AE
13	13303	1	1	*	UE
14	12055	1	0.83		UT
15	8642	1	0.85		UAL
16	11659	1	0.88		AA

ConstructID	n_eff	Rhat4	P_posterior	zero_excl	Construct
17	11969	1	0.79		AC
18	14164	1	0.7		AI
19	10384	1	0.6		AT
20	12528	1	0.74		SP
21	14857	1	0.62		IIS
22	13601	1	0.93		AEI
23	9932	1	0.78		UEP
24	14981	1	0.69		UAI

```
## Print grand means
Variable <- c("mean_German", "sd_German", "mean_Dutch", "sd_Dutch",
    "mean_diff", "sd_diff", "minimum_diff", "maximum_diff", "n_zero_excl",
    "percent_zero_excl")
# Calculate grand mean of mean_German, sd_German,
# mean_Dutch, sd_Dutch sd_diff, grand mean of the absolute
# value of mean differences, number of
# constructs/dimensions with credible bias indication, and
# percentage of these constructs/dimensions
Grand_mean <- c(mean(cul_list$mean_German), mean(cul_list$sd_German),
    mean(cul_list$mean_Dutch), mean(cul_list$sd_Dutch), mean(abs(cul_list$mean_diff)),
    mean(cul_list$sd_diff), min(cul_list$mean_diff), max(cul_list$mean_diff),
    sum(cul_list$zero_excl == "*"), round(sum(cul_list$zero_excl ==
        "*")/length(cul_list$ConstructID), digits = 4) * 100)
GrandMean <- cbind(Variable, Grand_mean)

pander(GrandMean, caption = "Grand mean of 24 constructs/dimensions between bilingual German and bilingu
```

Table 12: Grand mean of 24 constructs/dimensions between bilingual German and bilingual Dutch

Variable	Grand_mean
mean_German	0.5290625
sd_German	1.34375067260242
mean_Dutch	0.393732638888889
sd_Dutch	1.31774947186162
mean_diff	0.212052979944662
sd_diff	0.142647492282461
minimum_diff	-0.35964160193432
maximum_diff	0.579151217822857
n_zero_excl	8
percent_zero_excl	33.33