Improving memory for and production of singular they pronouns: Experiment 2

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Contents

Load data

Read data, preprocessed from PCIbex output. See data/exp2_data_readme for more details.

```
d_all <- read.csv("../data/exp2_data.csv", stringsAsFactors=TRUE) %>%
  rename("Biographies"="Story") #rename to match labeling in paper

d_all$Participant <- as.factor(d_all$Participant)
d_all$PSA <- as.factor(d_all$PSA)
d_all$Biographies <- as.factor(d_all$Biographies)
d_all$X <- NULL

str(d_all)
```

```
## 'data.frame':    11520 obs. of  18 variables:
##  $ Participant: Factor w/ 320 levels "1","2","3","4",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ SubjAge    : int  53 53 53 53 53 53 53 53 53 53 ...
##  $ SubjEnglish: Factor w/ 4 levels "Fully competent in speaking, listening, reading, and writing, bu
##  $ SubjGender : Factor w/ 2 levels "female","male": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Condition  : Factor w/ 4 levels "both","neither",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ List       : Factor w/ 12 levels "both_1","both_2",..: 1 1 1 1 1 1 1 1 1 1 ...
##  $ PSA        : Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Biographies: Factor w/ 2 levels "0","1": 2 2 2 2 2 2 2 2 2 2 ...
##  $ Name       : Factor w/ 12 levels "Amanda","Andrew",..: 2 2 7 2 7 1 1 7 6 6 ...
##  $ Job        : Factor w/ 12 levels "accountant","doctor",..: 11 11 4 11 4 3 3 4 6 6 ...
##  $ Pet        : Factor w/ 3 levels "cat","dog","fish": 2 2 3 2 3 1 1 3 2 2 ...
##  $ Pronoun    : Factor w/ 3 levels "he/him","she/her",..: 1 1 2 1 2 2 2 2 1 1 ...
##  $ M_Type     : Factor w/ 3 levels "job","pet","pronoun": 2 3 1 1 3 1 2 2 1 2 ...
##  $ M_Response : Factor w/ 18 levels "accountant","cat",..: 4 8 11 10 15 9 6 2 5 4 ...
##  $ M_Acc      : int  1 1 0 0 1 0 0 0 0 1 ...
##  $ P_Text     : Factor w/ 2918 levels " after the work he  play with the kids",..: NA 2625 NA NA 217
##  $ P_Response : Factor w/ 4 levels "he/him","none",..: NA 4 NA NA 3 NA NA NA NA NA ...
##  $ P_Acc      : int  NA 0 NA NA 1 NA NA NA NA NA ...
```

Set up contrast coding for Pronoun Type. The first contrast compares they to he+she. The second contrast compares he to she.

```
contrasts(d_all$Pronoun)=cbind("_T_HS"=c(.33,.33,-.66),
                               "_H_S"=c(-.5,.5, 0))
contrasts(d_all$Pronoun)
```

```
##           _T_HS _H_S
## he/him     0.33 -0.5
## she/her    0.33  0.5
## they/them -0.66  0.0
```

Set up contrast coding for PSA and Biographies conditions. .5 are the conditions related to singular they (gendered language PSA, they/them biographies); -.5 are the unrelated conditions (unrelated PSA, he/him and she/her biographies).

```
contrasts(d_all$PSA)=cbind("_GenLang"=c(-.5,.5))
contrasts(d_all$PSA)
```

```
##   _GenLang
## 0     -0.5
## 1      0.5
```

```
contrasts(d_all$Biographies)=cbind("_They"=c(-.5,.5))
contrasts(d_all$Biographies)
```

```
##   _They
## 0  -0.5
## 1   0.5
```

Remove pet and job rows, and the columns that aren't used in the models.

```
d <- d_all %>% filter (M_Type=="pronoun") %>%
  select(Participant, Condition, PSA, Biographies, Name, Pronoun,
         M_Acc, M_Response, P_Acc, P_Response)
```

By-participant mean accuracy for memory and production tasks.

```
d_subj <- d %>% group_by(PSA, Biographies, Participant, Pronoun) %>%
          summarize(M_Mean=mean(M_Acc), P_Mean=mean(P_Acc))
```

By-participant mean accuracy for production, split by memory accuracy.

```
d_acc <- d %>% group_by(PSA, Biographies, Participant, Pronoun, M_Acc) %>%
          summarize(P_Mean=mean(P_Acc))
```

If each participant selected/produced they/them at least once.

```
d_they <- d %>%
  mutate(M_IsThey=ifelse(M_Response=="they/them", 1, 0)) %>%
  mutate(P_IsThey=ifelse(P_Response=="they/them", 1, 0)) %>%
  group_by(Participant, Condition, PSA, Biographies) %>%
  summarize(M_Count=sum(M_IsThey),
            P_Count=sum(P_IsThey)) %>%
  mutate(M_UseThey=ifelse(M_Count!=0, 1, 0)) %>%
  mutate(P_UseThey=ifelse(P_Count!=0, 1, 0))
```

Memory

Descriptive Stats

Mean accuracy for all three memory question types.

```
d_all %>% group_by(M_Type) %>%
          summarise(acc=mean(M_Acc))
```

```
## # A tibble: 3 x 2
##   M_Type    acc
##   <fct>   <dbl>
## 1 job     0.365
## 2 pet     0.540
## 3 pronoun 0.716
```

Mean accuracy, split by Pronoun Type, PSA, and Biographies conditions. [Both = gendered language PSA + they biographies; PSA = gendered language PSA + he/she biographies; Story = unrelated PSA + they biographies; Neither = unrelated PSA + he/she biographies.]

```
d %>% group_by(Pronoun, Condition) %>%
      summarise(acc=mean(M_Acc))
```

```
## # A tibble: 12 x 3
## # Groups:   Pronoun [3]
##    Pronoun   Condition   acc
##    <fct>     <fct>     <dbl>
##  1 he/him    both      0.75
##  2 he/him    neither   0.819
##  3 he/him    psa       0.8
##  4 he/him    story     0.784
##  5 she/her   both      0.788
##  6 she/her   neither   0.825
##  7 she/her   psa       0.831
##  8 she/her   story     0.806
##  9 they/them both      0.572
## 10 they/them neither   0.525
## 11 they/them psa       0.588
## 12 they/them story     0.506
```

90-95% of participants selected they/them at least once.

```
d_they %>% group_by(Condition) %>%
  summarize(Select_They=sum(M_UseThey)) %>%
  mutate(n=80) %>%
  mutate(prop=Select_They/n)
```

```
## # A tibble: 4 x 4
##   Condition Select_They     n  prop
##   <fct>           <dbl> <dbl> <dbl>
## 1 both               76    80 0.95
## 2 neither            72    80 0.9
## 3 psa                73    80 0.912
## 4 story              74    80 0.925
```

Model

Full model has interactions between Pronoun (2 contrasts), PSA, and Biographies; random intercepts and slopes by participant and item. buildmer finds the maximal model that will converge (but doesn't then go backward to remove non-significant terms, the default setting). The final model includes all fixed effects/interactions and random intercepts by name.

```
model_m_full <- M_Acc ~ Pronoun * PSA * Biographies +
                (Pronoun|Participant) + (Pronoun|Name)

model_m <- buildmer(model_m_full, d,
           family="binomial", direction=c("order"))
```

```
## Determining predictor order

## Fitting via glm: M_Acc ~ 1

## Currently evaluating LRT for: Biographies, Pronoun, PSA

## Fitting via glm: M_Acc ~ 1 + Biographies
```

```
## Fitting via glm: M_Acc ~ 1 + Pronoun

## Fitting via glm: M_Acc ~ 1 + PSA

## Updating formula: M_Acc ~ 1 + Pronoun

## Currently evaluating LRT for: Biographies, PSA

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + PSA

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies

## Currently evaluating LRT for: Pronoun:Biographies, PSA

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies +
##     Pronoun:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA

## Currently evaluating LRT for: Pronoun:Biographies, Pronoun:PSA,
##     PSA:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     Pronoun:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     PSA:Biographies

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA

## Currently evaluating LRT for: Pronoun:Biographies, PSA:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + PSA:Biographies

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies

## Currently evaluating LRT for: PSA:Biographies
```

```
## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + PSA:Biographies

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + PSA:Biographies

## Currently evaluating LRT for: Pronoun:PSA:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + Biographies:PSA + Pronoun:PSA:Biographies

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + Biographies:PSA + Pronoun:PSA:Biographies

## Fitting via glm: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + Biographies:PSA + Pronoun:PSA:Biographies

## Currently evaluating LRT for: 1 | Name, 1 | Participant

## Fitting via glmer, with ML: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     Pronoun:PSA + Pronoun:Biographies + Biographies:PSA +
##     Pronoun:Biographies:PSA + (1 | Name)

## Fitting via glmer, with ML: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     Pronoun:PSA + Pronoun:Biographies + Biographies:PSA +
##     Pronoun:Biographies:PSA + (1 | Participant)

## Updating formula: M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA
##     + Pronoun:Biographies + Biographies:PSA + Pronoun:Biographies:PSA +
##     (1 | Name)

## Currently evaluating LRT for: Pronoun | Name, 1 | Participant

## Fitting via glmer, with ML: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     Pronoun:PSA + Pronoun:Biographies + Biographies:PSA +
##     Pronoun:Biographies:PSA + (1 + Pronoun | Name)

## boundary (singular) fit: see help('isSingular')

## Fitting via glmer, with ML: M_Acc ~ 1 + Pronoun + Biographies + PSA +
##     Pronoun:PSA + Pronoun:Biographies + Biographies:PSA +
##     Pronoun:Biographies:PSA + (1 | Name) + (1 | Participant)

## Ending the ordering procedure due to having reached the maximal
##     feasible model - all higher models failed to converge. The types of
##     convergence failure are: Singular fit lme4 reports not having
##     converged (-1)
```

```
summary(model_m)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) (p-values based on Wald z-scores) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## M_Acc ~ 1 + Pronoun + Biographies + PSA + Pronoun:PSA + Pronoun:Biographies +
##     Biographies:PSA + Pronoun:Biographies:PSA + (1 | Name)
##    Data: d
##
##      AIC      BIC   logLik deviance df.resid
##   4331.6   4412.9  -2152.8   4305.6     3827
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.2977 -1.0257  0.4830  0.5489  1.0425
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Name   (Intercept) 0.008349 0.09137
## Number of obs: 3840, groups:  Name, 12
##
## Fixed effects:
##                                          Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                               0.99624    0.04641 21.46737    0.000
## Pronoun_T_HS                              1.21757    0.07599 16.02350    0.000
## Pronoun_H_S                               0.14014    0.11078  1.26496    0.206
## Biographies_They                         -0.17570    0.07625 -2.30426    0.021
## PSA_GenLang                               0.02205    0.07625  0.28920    0.772
## Pronoun_T_HS:PSA_GenLang                 -0.36169    0.15193 -2.38062    0.017
## Pronoun_H_S:PSA_GenLang                   0.12121    0.19910  0.60879    0.543
## Pronoun_T_HS:Biographies_They            -0.16107    0.15192 -1.06024    0.289
## Pronoun_H_S:Biographies_They              0.04874    0.19911  0.24476    0.807
## Biographies_They:PSA_GenLang             -0.07341    0.15251 -0.48136    0.630
## Pronoun_T_HS:Biographies_They:PSA_GenLang -0.13107    0.30389 -0.43131    0.666
## Pronoun_H_S:Biographies_They:PSA_GenLang  -0.08755    0.39833 -0.21980    0.826
##                                          Pr(>|t|)
## (Intercept)                                <2e-16 ***
## Pronoun_T_HS                               <2e-16 ***
## Pronoun_H_S                                0.2059
## Biographies_They                           0.0212 *
## PSA_GenLang                                0.7724
## Pronoun_T_HS:PSA_GenLang                   0.0173 *
## Pronoun_H_S:PSA_GenLang                    0.5427
## Pronoun_T_HS:Biographies_They              0.2890
## Pronoun_H_S:Biographies_They               0.8066
## Biographies_They:PSA_GenLang               0.6303
## Pronoun_T_HS:Biographies_They:PSA_GenLang  0.6662
## Pronoun_H_S:Biographies_They:PSA_GenLang   0.8260
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
```

```
##             (Intr) Pr_T_HS Pr_H_S Bgrp_T PSA_GL P_T_HS:P P_H_S:P Pr_T_HS:B_T
## Pronon_T_HS  0.171
## Pronoun_H_S  0.025  0.024
## Bigrphs_Thy -0.043 -0.038   0.001
## PSA_GenLang -0.013 -0.019   0.013 -0.011
## P_T_HS:PSA_ -0.016 -0.004   0.011 -0.007  0.207
## P_H_S:PSA_G  0.012  0.011  -0.023 -0.009  0.038  0.029
## Pr_T_HS:B_T -0.031 -0.031   0.001  0.207 -0.007 -0.007   -0.007
## Prn_H_S:B_T  0.001  0.001  -0.061  0.038 -0.009 -0.007   -0.014   0.029
## Bg_T:PSA_GL -0.009 -0.007  -0.008 -0.016 -0.052 -0.038    0.001  -0.019
## P_T_HS:B_T: -0.007 -0.007  -0.006 -0.019 -0.038 -0.031    0.001  -0.004
## P_H_S:B_T:P -0.007 -0.007  -0.013  0.014  0.001  0.001   -0.067   0.011
##             Pr_H_S:B_T B_T:PS P_T_HS:B_T:
## Pronon_T_HS
## Pronoun_H_S
## Bigrphs_Thy
## PSA_GenLang
## P_T_HS:PSA_
## P_H_S:PSA_G
## Pr_T_HS:B_T
## Prn_H_S:B_T
## Bg_T:PSA_GL  0.014
## P_T_HS:B_T:  0.011      0.207
## P_H_S:B_T:P -0.025      0.038  0.029
```

Production

Descriptive Stats

Mean accuracy, split by Pronoun Type, PSA, and Biographies conditions. [Both = gendered language PSA + they biographies; PSA = gendered language PSA + he/she biographies; Story = unrelated PSA + they biographies; Neither = unrelated PSA + he/she biographies.]

```
d %>% group_by(Pronoun, Condition) %>%
      summarise(m=mean(P_Acc))
```

```
## # A tibble: 12 x 3
## # Groups:   Pronoun [3]
##    Pronoun   Condition     m
##    <fct>     <fct>     <dbl>
##  1 he/him    both      0.834
##  2 he/him    neither   0.919
##  3 he/him    psa       0.809
##  4 he/him    story     0.875
##  5 she/her   both      0.828
##  6 she/her   neither   0.884
##  7 she/her   psa       0.778
##  8 she/her   story     0.828
##  9 they/them both      0.328
## 10 they/them neither   0.106
## 11 they/them psa       0.334
## 12 they/them story     0.119
```

Model

Same model specifications as before. The maximal model contains all fixed effects/interactions and by-item random intercepts.

```
model_p_full <- P_Acc ~ Pronoun * PSA * Biographies +
                (Pronoun|Participant) + (Pronoun|Name)

model_p <- buildmer(model_p_full, d,
           family="binomial", direction=c("order"))
```

```
## Determining predictor order

## Fitting via glm: P_Acc ~ 1

## Currently evaluating LRT for: Biographies, Pronoun, PSA

## Fitting via glm: P_Acc ~ 1 + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun

## Fitting via glm: P_Acc ~ 1 + PSA

## Updating formula: P_Acc ~ 1 + Pronoun

## Currently evaluating LRT for: Biographies, PSA

## Fitting via glm: P_Acc ~ 1 + Pronoun + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA

## Updating formula: P_Acc ~ 1 + Pronoun + PSA

## Currently evaluating LRT for: Biographies, Pronoun:PSA

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA

## Currently evaluating LRT for: Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies

## Currently evaluating LRT for: Pronoun:Biographies, PSA:Biographies
```

```
## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies

## Currently evaluating LRT for: Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies

## Currently evaluating LRT for: Pronoun:PSA:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies + Pronoun:PSA:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies + Pronoun:PSA:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies + Pronoun:PSA:Biographies

## Currently evaluating LRT for: 1 | Name, 1 | Participant

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA +
##     Biographies + PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + (1 | Name)

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA +
##     Biographies + PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + (1 | Participant)

## Updating formula: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies
##     + PSA:Biographies + Pronoun:Biographies + Pronoun:PSA:Biographies +
##     (1 | Name)

## Currently evaluating LRT for: Pronoun | Name, 1 | Participant

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA +
##     Biographies + PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + (1 + Pronoun | Name)

## boundary (singular) fit: see help('isSingular')
```

```
## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA +
##     Biographies + PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + (1 | Name) + (1 | Participant)

## Ending the ordering procedure due to having reached the maximal
##     feasible model - all higher models failed to converge. The types of
##     convergence failure are: Singular fit lme4 reports not having
##     converged (-1)
```

```
summary(model_p)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) (p-values based on Wald z-scores) [glmerMod]
##  Family: binomial  ( logit )
## Formula:
## P_Acc ~ 1 + Pronoun + PSA + Pronoun:PSA + Biographies + PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies + (1 | Name)
##    Data: d
##
##      AIC      BIC   logLik deviance df.resid
##   3464.0   3545.3  -1719.0   3438.0     3827
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.4309 -0.3672  0.3616  0.4550  3.0688
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Name   (Intercept) 0.007172 0.08469
## Number of obs: 3840, groups:  Name, 12
##
## Fixed effects:
##                                          Estimate Std. Error  z value Pr(>|z|)
## (Intercept)                               0.69508    0.05161 13.46873    0.000
## Pronoun_T_HS                              3.15560    0.09577 32.95093    0.000
## Pronoun_H_S                              -0.26080    0.12341 -2.11336    0.035
## PSA_GenLang                               0.10699    0.09085  1.17767    0.239
## Biographies_They                         -0.05933    0.09084 -0.65305    0.514
## Pronoun_T_HS:PSA_GenLang                 -1.90734    0.19075 -9.99914    0.000
## Pronoun_H_S:PSA_GenLang                   0.26552    0.22695  1.16994    0.242
## PSA_GenLang:Biographies_They              0.42601    0.18168  2.34483    0.019
## Pronoun_T_HS:Biographies_They            -0.16030    0.19077 -0.84028    0.401
## Pronoun_H_S:Biographies_They              0.08454    0.22696  0.37248    0.710
## Pronoun_T_HS:PSA_GenLang:Biographies_They  0.88225    0.38148  2.31271    0.021
## Pronoun_H_S:PSA_GenLang:Biographies_They   0.13413    0.45382  0.29555    0.768
##                                          Pr(>|t|)
## (Intercept)                                <2e-16 ***
## Pronoun_T_HS                               <2e-16 ***
## Pronoun_H_S                                0.0346 *
## PSA_GenLang                                0.2389
## Biographies_They                           0.5137
## Pronoun_T_HS:PSA_GenLang                   <2e-16 ***
## Pronoun_H_S:PSA_GenLang                    0.2420
```

```
## PSA_GenLang:Biographies_They                0.0190 *
## Pronoun_T_HS:Biographies_They               0.4007
## Pronoun_H_S:Biographies_They                0.7095
## Pronoun_T_HS:PSA_GenLang:Biographies_They   0.0207 *
## Pronoun_H_S:PSA_GenLang:Biographies_They    0.7676
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##                (Intr) Pr_T_HS Pr_H_S PSA_GnL Bgrp_T Pr_T_HS:PSA_GL
## Pronon_T_HS     0.054
## Pronoun_H_S    -0.071 -0.066
## PSA_GenLang    -0.221  0.071   0.056
## Bigrphs_Thy    -0.055 -0.024   0.023  0.105
## Pr_T_HS:PSA_GL  0.062 -0.312   0.042  0.058   0.053
## Pr_H_S:PSA_GL   0.054  0.044  -0.179 -0.084  -0.013 -0.060
## PSA_GnL:B_T     0.093  0.053  -0.012 -0.063  -0.251 -0.024
## Pr_T_HS:B_T    -0.020 -0.045   0.014  0.053   0.058  0.071
## Prn_H_S:B_T     0.022  0.019  -0.071 -0.013  -0.084 -0.010
## P_T_HS:PSA_GL:  0.047  0.073  -0.010 -0.024   0.071 -0.048
## P_H_S:PSA_GL:  -0.011 -0.008   0.124  0.025   0.061  0.018
##                Pr_H_S:PSA_GL PSA_GL: P_T_HS:B P_H_S:B P_T_HS:PSA_GL:
## Pronon_T_HS
## Pronoun_H_S
## PSA_GenLang
## Bigrphs_Thy
## Pr_T_HS:PSA_GL
## Pr_H_S:PSA_GL
## PSA_GnL:B_T     0.025
## Pr_T_HS:B_T    -0.009         0.071
## Prn_H_S:B_T     0.136         0.061  -0.060
## P_T_HS:PSA_GL:  0.018         0.058  -0.312    0.044
## P_H_S:PSA_GL:  -0.076        -0.084   0.044   -0.194  -0.060
```

Three-Way Interaction

The main model has Helmert coding for Pronoun and Effects coding (.5, -.5) for PSA and Biographies. This means Pronoun (T vs HS) * PSA * Biographies is testing the interaction between Pronoun and PSA across both Biographies conditions.

Dummy coding Biographies with they/them biographies as 1 and he/she biographies as 0 tests the interaction between Pronoun and PSA for just the he/she Biographies:

```
d %<>% mutate(BioDummy_T=Biographies)
contrasts(d$BioDummy_T)=cbind("_They1"=c(0,1))

model_p_dummyT <- glmer(P_Acc ~ Pronoun * PSA * BioDummy_T + (1|Name),
                  data=d, family="binomial")

summary(model_p_dummyT)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
```

```
##  Family: binomial  ( logit )
## Formula: P_Acc ~ Pronoun * PSA * BioDummy_T + (1 | Name)
##    Data: d
##
##      AIC      BIC   logLik deviance df.resid
##   3464.0   3545.3  -1719.0   3438.0     3827
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.4309 -0.3672  0.3616  0.4550  3.0687
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Name   (Intercept) 0.007172 0.08469
## Number of obs: 3840, groups:  Name, 12
##
## Fixed effects:
##                                             Estimate Std. Error z value Pr(>|z|)
## (Intercept)                                  0.72475    0.07060  10.265   <2e-16
## Pronoun_T_HS                                 3.23575    0.13822  23.411   <2e-16
## Pronoun_H_S                                 -0.30307    0.17352  -1.747   0.0807
## PSA_GenLang                                 -0.10602    0.13243  -0.801   0.4234
## BioDummy_T_They1                            -0.05933    0.09085  -0.653   0.5137
## Pronoun_T_HS:PSA_GenLang                    -2.34842    0.27618  -8.503   <2e-16
## Pronoun_H_S:PSA_GenLang                      0.19845    0.33288   0.596   0.5511
## Pronoun_T_HS:BioDummy_T_They1               -0.16029    0.19079  -0.840   0.4008
## Pronoun_H_S:BioDummy_T_They1                 0.08451    0.22697   0.372   0.7096
## PSA_GenLang:BioDummy_T_They1                 0.42602    0.18169   2.345   0.0190
## Pronoun_T_HS:PSA_GenLang:BioDummy_T_They1    0.88220    0.38159   2.312   0.0208
## Pronoun_H_S:PSA_GenLang:BioDummy_T_They1     0.13412    0.45385   0.296   0.7676
##
## (Intercept)                                 ***
## Pronoun_T_HS                                ***
## Pronoun_H_S                                 .
## PSA_GenLang
## BioDummy_T_They1
## Pronoun_T_HS:PSA_GenLang                    ***
## Pronoun_H_S:PSA_GenLang
## Pronoun_T_HS:BioDummy_T_They1
## Pronoun_H_S:BioDummy_T_They1
## PSA_GenLang:BioDummy_T_They1                *
## Pronoun_T_HS:PSA_GenLang:BioDummy_T_They1 *
## Pronoun_H_S:PSA_GenLang:BioDummy_T_They1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##                (Intr) Pr_T_HS Pr_H_S PSA_GnL BD_T_T Pr_T_HS:PSA_GL
## Pronon_T_HS     0.074
## Pronoun_H_S    -0.093 -0.075
## PSA_GenLang    -0.314  0.017   0.066
## BDmmy_T_Th1    -0.684 -0.056   0.071  0.244
## Pr_T_HS:PSA_GL  0.015 -0.367   0.050  0.078  -0.012
## Pr_H_S:PSA_GL   0.065  0.050  -0.294 -0.102  -0.050 -0.073
```

```
## P_T_HS:BD_T    -0.052 -0.722   0.049 -0.012   0.058  0.265
## P_H_S:BD_T_     0.070  0.055  -0.705 -0.051  -0.084 -0.037
## PSA_GL:BD_T     0.229 -0.012  -0.049 -0.729  -0.251 -0.057
## P_T_HS:PSA_GL: -0.011  0.266  -0.036 -0.056   0.071 -0.724
## P_H_S:PSA_GL:  -0.047 -0.036   0.215  0.074   0.061  0.054
##                Pr_H_S:PSA_GL P_T_HS:B P_H_S:B PSA_GL: P_T_HS:PSA_GL:
## Pronon_T_HS
## Pronoun_H_S
## PSA_GenLang
## BDmmy_T_Th1
## Pr_T_HS:PSA_GL
## Pr_H_S:PSA_GL
## P_T_HS:BD_T    -0.036
## P_H_S:BD_T_     0.225        -0.060
## PSA_GL:BD_T     0.074         0.071    0.061
## P_T_HS:PSA_GL:  0.053        -0.312    0.044   0.058
## P_H_S:PSA_GL:  -0.733         0.044   -0.194  -0.084  -0.060
```

Conversely, dummy coding Biographies with he/she biographies as 1 and they biographies as 0 tests the interaction between Pronoun and PSA for just the they Biographies.

```
d %<>% mutate(BioDummy_HS=Biographies)
contrasts(d$BioDummy_HS)=cbind("_HeShe"=c(1,0))

model_p_dummyHS <- glmer(P_Acc ~ Pronoun * PSA * BioDummy_HS + (1|Name),
                         data=d, family="binomial")
summary(model_p_dummyHS)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) [glmerMod]
##  Family: binomial  ( logit )
## Formula: P_Acc ~ Pronoun * PSA * BioDummy_HS + (1 | Name)
##    Data: d
##
##      AIC      BIC   logLik deviance df.resid
##   3464.0   3545.3  -1719.0   3438.0     3827
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.4310 -0.3672  0.3616  0.4550  3.0688
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Name   (Intercept) 0.007173 0.08469
## Number of obs: 3840, groups:  Name, 12
##
## Fixed effects:
##                                      Estimate Std. Error z value Pr(>|z|)
## (Intercept)                           0.66541    0.06685   9.954  < 2e-16
## Pronoun_T_HS                          3.07546    0.13207  23.286  < 2e-16
## Pronoun_H_S                          -0.21855    0.16160  -1.352   0.1762
## PSA_GenLang                           0.31999    0.12441   2.572   0.0101
## BioDummy_HS_HeShe                     0.05934    0.09085   0.653   0.5137
```

```
## Pronoun_T_HS:PSA_GenLang                    -1.46623    0.26337  -5.567 2.59e-08
## Pronoun_H_S:PSA_GenLang                      0.33259    0.30870   1.077   0.2813
## Pronoun_T_HS:BioDummy_HS_HeShe               0.16030    0.19081   0.840   0.4008
## Pronoun_H_S:BioDummy_HS_HeShe               -0.08453    0.22703  -0.372   0.7096
## PSA_GenLang:BioDummy_HS_HeShe               -0.42602    0.18172  -2.344   0.0191
## Pronoun_T_HS:PSA_GenLang:BioDummy_HS_HeShe -0.88224    0.38179  -2.311   0.0208
## Pronoun_H_S:PSA_GenLang:BioDummy_HS_HeShe  -0.13417    0.45422  -0.295   0.7677
##
## (Intercept)                                ***
## Pronoun_T_HS                               ***
## Pronoun_H_S
## PSA_GenLang                                *
## BioDummy_HS_HeShe
## Pronoun_T_HS:PSA_GenLang                   ***
## Pronoun_H_S:PSA_GenLang
## Pronoun_T_HS:BioDummy_HS_HeShe
## Pronoun_H_S:BioDummy_HS_HeShe
## PSA_GenLang:BioDummy_HS_HeShe              *
## Pronoun_T_HS:PSA_GenLang:BioDummy_HS_HeShe *
## Pronoun_H_S:PSA_GenLang:BioDummy_HS_HeShe
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##                (Intr) Pr_T_HS Pr_H_S PSA_GnL BD_HS_ Pr_T_HS:PSA_GL
## Pronon_T_HS     0.035
## Pronoun_H_S    -0.058 -0.049
## PSA_GenLang    -0.145  0.131   0.049
## BDmmy_HS_HS    -0.637 -0.025   0.041  0.106
## Pr_T_HS:PSA_GL  0.122 -0.252   0.035  0.036  -0.090
## Pr_H_S:PSA_GL   0.049  0.038  -0.061 -0.063  -0.035 -0.045
## P_T_HS:BD_H    -0.024 -0.689   0.031 -0.090   0.058  0.174
## P_H_S:BD_HS     0.040  0.029  -0.648 -0.035  -0.084 -0.025
## PSA_GL:BD_H     0.099 -0.090  -0.034 -0.685  -0.251 -0.025
## P_T_HS:PSA_GL: -0.084  0.172  -0.023 -0.025   0.071 -0.690
## P_H_S:PSA_GL:  -0.033 -0.026   0.042  0.043   0.061  0.031
##                Pr_H_S:PSA_GL P_T_HS:B P_H_S:B PSA_GL: P_T_HS:PSA_GL:
## Pronon_T_HS
## Pronoun_H_S
## PSA_GenLang
## BDmmy_HS_HS
## Pr_T_HS:PSA_GL
## Pr_H_S:PSA_GL
## P_T_HS:BD_H    -0.026
## P_H_S:BD_HS     0.042        -0.060
## PSA_GL:BD_H     0.043         0.071    0.061
## P_T_HS:PSA_GL:  0.031        -0.312    0.044   0.058
## P_H_S:PSA_GL:  -0.680         0.044   -0.194  -0.084  -0.060
```

The three models to compare:

```
interaction_1 <- tidy(model_p@model) %>%
  select(term, estimate, p.value) %>%
  filter(term=="Pronoun_T_HS" | term=="PSA_GenLang" |
```

```
          term=="Pronoun_T_HS:PSA_GenLang") %>%
  rename("AcrossBio_Est"="estimate", "AcrossBio_p"="p.value")

interaction_2 <- tidy(model_p_dummyT) %>%
  select(term, estimate, p.value) %>%
  filter(term=="Pronoun_T_HS" | term=="PSA_GenLang" |
          term=="Pronoun_T_HS:PSA_GenLang") %>%
  rename("HeSheBio_Est"="estimate", "HeSheBio_p"="p.value") %>%
  left_join(interaction_1)
```

```
## Joining, by = "term"
```

```
interaction_3 <- tidy(model_p_dummyHS) %>%
  select(term, estimate, p.value) %>%
  filter(term=="Pronoun_T_HS" | term=="PSA_GenLang" |
          term=="Pronoun_T_HS:PSA_GenLang") %>%
  rename("TheyBio_Est"="estimate", "TheyBio_p"="p.value") %>%
  left_join(interaction_2)
```

```
## Joining, by = "term"
```

```
interaction_3
```

```
## # A tibble: 3 x 7
##   term   TheyBio_Est TheyBio_p HeSheBio_Est HeSheBio_p AcrossBio_Est AcrossBio_p
##   <chr>        <dbl>     <dbl>        <dbl>      <dbl>         <dbl>       <dbl>
## 1 Prono~       3.08  6.17e-120        3.24   3.32e-121         3.16    4.10e-238
## 2 PSA_G~       0.320 1.01e-  2       -0.106  4.23e-  1         0.107   2.39e-  1
## 3 Prono~      -1.47  2.59e-  8       -2.35   1.84e- 17        -1.91    1.54e- 23
```

The estimate for the PSA*Pronoun interaction is -2.34 for the he/she biographies and -1.47 for the they biographies, which means that the pronoun PSA reduced the relative difficulty of they/them more when paired with the he/she biographies than with they biographies. Connecting to the plot, the PSA-Neither difference is larger than Both-Story difference.

Producing they/them at least once

```
d %>% filter(P_Response=="they/them") %>%
  group_by(Condition) %>%
  summarize(they=n_distinct(Participant)) %>%
  mutate(n=80) %>%
  mutate(prop=they/n)
```

```
## # A tibble: 4 x 4
##   Condition  they     n  prop
##   <fct>     <int> <dbl> <dbl>
## 1 both         38    80 0.475
## 2 neither      21    80 0.262
## 3 psa          46    80 0.575
## 4 story        28    80 0.35
```

Model with whether each participant produced they/them at least once as the outcome variable. Higher with the gendered language PSA, no effect of Biographies, vaguely trending interaction.

```
model_p_they <- glm(P_UseThey ~ PSA * Biographies,
                d_they, family="binomial")
summary(model_p_they)
```

```
##
## Call:
## glm(formula = P_UseThey ~ PSA * Biographies, family = "binomial",
##     data = d_they)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.3082  -0.9282  -0.7804   1.2202   1.6356
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)                  -0.362464   0.117471  -3.086  0.00203 **
## PSA_GenLang                   0.927126   0.234941   3.946 7.94e-05 ***
## Biographies_They              0.005806   0.234941   0.025  0.98029
## PSA_GenLang:Biographies_They -0.816340   0.469882  -1.737  0.08233 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 434.46  on 319  degrees of freedom
## Residual deviance: 415.50  on 316  degrees of freedom
## AIC: 423.5
##
## Number of Fisher Scoring iterations: 4
```

Memory Predicting Production

Descriptive Stats

```
d %>% group_by(Pronoun, Condition, M_Acc) %>%
      summarise(m=mean(P_Acc))
```

```
## # A tibble: 24 x 4
## # Groups:   Pronoun, Condition [12]
##    Pronoun Condition M_Acc     m
##    <fct>   <fct>     <int> <dbl>
##  1 he/him  both          0 0.738
##  2 he/him  both          1 0.867
##  3 he/him  neither       0 0.879
##  4 he/him  neither       1 0.927
##  5 he/him  psa           0 0.781
##  6 he/him  psa           1 0.816
```

```
##  7 he/him  story         0 0.812
##  8 he/him  story         1 0.892
##  9 she/her both          0 0.721
## 10 she/her both          1 0.857
## # ... with 14 more rows
```

Combining the two measures, there are 4 possible patterns: getting both right, getting both wrong, getting just memory right, and getting just production right.

```
mp_acc <- d %>%
          mutate(BothRight=ifelse(M_Acc==1 & P_Acc==1, 1, 0)) %>%
          mutate(BothWrong=ifelse(M_Acc==0 & P_Acc==0, 1, 0)) %>%
          mutate(MemOnly=ifelse(M_Acc==1 & P_Acc==0, 1, 0)) %>%
          mutate(ProdOnly=ifelse(M_Acc==0 & P_Acc==1, 1, 0)) %>%
          pivot_longer(cols=c(BothRight, BothWrong, MemOnly, ProdOnly),
                       names_to="Combined_Accuracy") %>%
          group_by(Pronoun, Combined_Accuracy) %>%
          summarise(m=mean(value))
mp_acc
```

```
## # A tibble: 12 x 3
## # Groups:   Pronoun [3]
##    Pronoun   Combined_Accuracy      m
##    <fct>     <chr>              <dbl>
##  1 he/him    BothRight         0.691
##  2 he/him    BothWrong         0.0430
##  3 he/him    MemOnly           0.0977
##  4 he/him    ProdOnly          0.169
##  5 she/her   BothRight         0.695
##  6 she/her   BothWrong         0.0531
##  7 she/her   MemOnly           0.117
##  8 she/her   ProdOnly          0.134
##  9 they/them BothRight         0.166
## 10 they/them BothWrong         0.397
## 11 they/them MemOnly           0.381
## 12 they/them ProdOnly          0.0555
```

Model

Maximal model has interactions between Pronoun (2 contrasts), Memory Accuracy, PSA, and Biographies, then random intercepts by item.

```
model_mp_full <- P_Acc ~ Pronoun * PSA * Biographies * M_Acc +
                 (Pronoun|Participant) + (Pronoun|Name)

model_mp <- buildmer(model_mp_full, d,
                     family="binomial", direction=c("order"))
```

```
## Determining predictor order
```

```
## Fitting via glm: P_Acc ~ 1
```

```
## Currently evaluating LRT for: Biographies, M_Acc, Pronoun, PSA

## Fitting via glm: P_Acc ~ 1 + Biographies

## Fitting via glm: P_Acc ~ 1 + M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun

## Fitting via glm: P_Acc ~ 1 + PSA

## Updating formula: P_Acc ~ 1 + Pronoun

## Currently evaluating LRT for: Biographies, M_Acc, PSA

## Fitting via glm: P_Acc ~ 1 + Pronoun + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + PSA

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc

## Currently evaluating LRT for: Biographies, Pronoun:M_Acc, PSA

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + Pronoun:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA

## Currently evaluating LRT for: Biographies, Pronoun:M_Acc, Pronoun:PSA,
##     PSA:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + PSA:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA

## Currently evaluating LRT for: Biographies, Pronoun:M_Acc, PSA:M_Acc
```

```
## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     PSA:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc

## Currently evaluating LRT for: Biographies, PSA:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + PSA:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + PSA:M_Acc

## Currently evaluating LRT for: Biographies, Pronoun:PSA:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:PSA:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:PSA:M_Acc

## Currently evaluating LRT for: Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies

## Currently evaluating LRT for: Biographies:M_Acc, Pronoun:Biographies,
##     PSA:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     Biographies:M_Acc
```

```
## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies

## Currently evaluating LRT for: Biographies:M_Acc, Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + Pronoun:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + Biographies:M_Acc

## Currently evaluating LRT for: Pronoun:Biographies,
##     PSA:Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + PSA:Biographies:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + PSA:Biographies:M_Acc

## Currently evaluating LRT for: Pronoun:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies
```

```
## Currently evaluating LRT for: Pronoun:Biographies:M_Acc,
##     Pronoun:PSA:Biographies

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies

## Currently evaluating LRT for: Pronoun:Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:Biographies:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:Biographies:M_Acc

## Currently evaluating LRT for: Pronoun:PSA:Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:M_Acc:Biographies + Pronoun:PSA:Biographies:M_Acc

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:M_Acc:Biographies + Pronoun:PSA:Biographies:M_Acc

## Fitting via glm: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:M_Acc:Biographies + Pronoun:PSA:Biographies:M_Acc
```

```
## Currently evaluating LRT for: 1 | Name, 1 | Participant

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + M_Acc + PSA +
##     Pronoun:PSA + Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA +
##     Biographies + PSA:Biographies + M_Acc:Biographies +
##     M_Acc:PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + Pronoun:M_Acc:Biographies +
##     Pronoun:M_Acc:PSA:Biographies + (1 | Name)

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + M_Acc + PSA +
##     Pronoun:PSA + Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA +
##     Biographies + PSA:Biographies + M_Acc:Biographies +
##     M_Acc:PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + Pronoun:M_Acc:Biographies +
##     Pronoun:M_Acc:PSA:Biographies + (1 | Participant)

## Updating formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA +
##     Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies +
##     PSA:Biographies + M_Acc:Biographies + M_Acc:PSA:Biographies +
##     Pronoun:Biographies + Pronoun:PSA:Biographies +
##     Pronoun:M_Acc:Biographies + Pronoun:M_Acc:PSA:Biographies + (1 |
##     Name)

## Currently evaluating LRT for: Pronoun | Name, 1 | Participant

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + M_Acc + PSA +
##     Pronoun:PSA + Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA +
##     Biographies + PSA:Biographies + M_Acc:Biographies +
##     M_Acc:PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + Pronoun:M_Acc:Biographies +
##     Pronoun:M_Acc:PSA:Biographies + (1 + Pronoun | Name)

## boundary (singular) fit: see help('isSingular')

## Fitting via glmer, with ML: P_Acc ~ 1 + Pronoun + M_Acc + PSA +
##     Pronoun:PSA + Pronoun:M_Acc + M_Acc:PSA + Pronoun:M_Acc:PSA +
##     Biographies + PSA:Biographies + M_Acc:Biographies +
##     M_Acc:PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + Pronoun:M_Acc:Biographies +
##     Pronoun:M_Acc:PSA:Biographies + (1 | Name) + (1 | Participant)

## Ending the ordering procedure due to having reached the maximal
##     feasible model - all higher models failed to converge. The types of
##     convergence failure are: Singular fit lme4 reports not having
##     converged (-1)
```

```
summary(model_mp)
```

```
## Generalized linear mixed model fit by maximum likelihood (Laplace
##   Approximation) (p-values based on Wald z-scores) [glmerMod]
##  Family: binomial  ( logit )
```

```
## Formula: P_Acc ~ 1 + Pronoun + M_Acc + PSA + Pronoun:PSA + Pronoun:M_Acc +
##     M_Acc:PSA + Pronoun:M_Acc:PSA + Biographies + PSA:Biographies +
##     M_Acc:Biographies + M_Acc:PSA:Biographies + Pronoun:Biographies +
##     Pronoun:PSA:Biographies + Pronoun:M_Acc:Biographies + Pronoun:M_Acc:PSA:Biographies +
##     (1 | Name)
##    Data: d
##
##      AIC      BIC   logLik deviance df.resid
##   3384.0   3540.3  -1667.0   3334.0     3815
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -3.6071 -0.4348  0.3461  0.4641  4.9870
##
## Random effects:
##  Groups Name        Variance Std.Dev.
##  Name   (Intercept) 0.003596 0.05996
## Number of obs: 3840, groups:  Name, 12
##
## Fixed effects:
##                                                 Estimate Std. Error  z value
## (Intercept)                                      0.10688    0.08987  1.18937
## Pronoun_T_HS                                     3.33124    0.18516 17.99081
## Pronoun_H_S                                     -0.46920    0.22284 -2.10556
## M_Acc                                            0.83019    0.10374  8.00239
## PSA_GenLang                                     -0.04541    0.17616 -0.25777
## Biographies_They                                 0.04027    0.17617  0.22858
## Pronoun_T_HS:PSA_GenLang                        -1.77795    0.36947 -4.81210
## Pronoun_H_S:PSA_GenLang                         -0.12067    0.44046 -0.27396
## Pronoun_T_HS:M_Acc                              -0.40183    0.21858 -1.83842
## Pronoun_H_S:M_Acc                                0.25503    0.25851  0.98651
## M_Acc:PSA_GenLang                                0.23980    0.20735  1.15653
## PSA_GenLang:Biographies_They                     0.16487    0.35233  0.46794
## M_Acc:Biographies_They                          -0.11428    0.20738 -0.55105
## Pronoun_T_HS:Biographies_They                   -0.71912    0.36942 -1.94664
## Pronoun_H_S:Biographies_They                     0.36914    0.44050  0.83800
## Pronoun_T_HS:M_Acc:PSA_GenLang                  -0.23686    0.43705 -0.54195
## Pronoun_H_S:M_Acc:PSA_GenLang                    0.48046    0.51606  0.93101
## M_Acc:PSA_GenLang:Biographies_They               0.42514    0.41472  1.02512
## Pronoun_T_HS:PSA_GenLang:Biographies_They        1.96223    0.74028  2.65066
## Pronoun_H_S:PSA_GenLang:Biographies_They         1.04670    0.88132  1.18765
## Pronoun_T_HS:M_Acc:Biographies_They              0.83020    0.43694  1.90005
## Pronoun_H_S:M_Acc:Biographies_They               -0.38998    0.51604 -0.75571
## Pronoun_T_HS:M_Acc:PSA_GenLang:Biographies_They -1.52764    0.87578 -1.74431
## Pronoun_H_S:M_Acc:PSA_GenLang:Biographies_They  -1.20247    1.03266 -1.16445
##                                                 Pr(>|z|) Pr(>|t|)
## (Intercept)                                        0.234  0.23429
## Pronoun_T_HS                                       0.000  < 2e-16 ***
## Pronoun_H_S                                        0.035  0.03524 *
## M_Acc                                              0.000 1.22e-15 ***
## PSA_GenLang                                        0.797  0.79659
## Biographies_They                                   0.819  0.81919
## Pronoun_T_HS:PSA_GenLang                           0.000 1.49e-06 ***
## Pronoun_H_S:PSA_GenLang                            0.784  0.78411
```

```
## Pronoun_T_HS:M_Acc                                    0.066  0.06600 .
## Pronoun_H_S:M_Acc                                     0.324  0.32388
## M_Acc:PSA_GenLang                                     0.247  0.24746
## PSA_GenLang:Biographies_They                          0.640  0.63983
## M_Acc:Biographies_They                                0.582  0.58160
## Pronoun_T_HS:Biographies_They                         0.052  0.05158 .
## Pronoun_H_S:Biographies_They                          0.402  0.40203
## Pronoun_T_HS:M_Acc:PSA_GenLang                        0.588  0.58785
## Pronoun_H_S:M_Acc:PSA_GenLang                         0.352  0.35185
## M_Acc:PSA_GenLang:Biographies_They                    0.305  0.30531
## Pronoun_T_HS:PSA_GenLang:Biographies_They             0.008  0.00803 **
## Pronoun_H_S:PSA_GenLang:Biographies_They              0.235  0.23497
## Pronoun_T_HS:M_Acc:Biographies_They                   0.057  0.05743 .
## Pronoun_H_S:M_Acc:Biographies_They                    0.450  0.44982
## Pronoun_T_HS:M_Acc:PSA_GenLang:Biographies_They       0.081  0.08111 .
## Pronoun_H_S:M_Acc:PSA_GenLang:Biographies_They        0.244  0.24424
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

##
## Correlation matrix not shown by default, as p = 24 > 12.
## Use print(x, correlation=TRUE)  or
##     vcov(x)        if you need it
```