Study 2 Analysis: Men's Voices

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Introduction

This study investigates the social evaluative implications of sensory adaptation to men's voices.

Stimuli. Test stimuli were audio recordings of 20 young adult men reciting the sentence "Hi, I'm a student at UCLA". Samples were recorded digitally (M-Audio Microtrack recorder, 16-bit amplitude resolution, 44.1 kHz sampling rate) using an AKG E535 condenser microphone placed approximately 15cm from the mouth. Stimuli varied naturally in duration, fundamental frequency (F_0), and voice quality.

Adapting stimuli. Adaptors included both masculinized and feminized exemplars that would be gender-typical and gender-atypical, respectively, relative to test stimuli. Adaptors were generated from recordings of 5 young adult men producing the same sentence as test stimuli. These recordings were manipulated to be more masculine or more feminine using the VT-Change script in Praat (Boersma & Weenink, 2021). We altered F_0, a well-established sexually dimorphic aspect of voice, using PSOLA (Pitch Synchronous Overlap Add) resynthesis. For masculinized versions, F_0 values were lowered to 90% of baseline. For feminized versions, F_0 was increased to 175% of baseline.

Procedure. We recruited U.S. residents from Prolific. After providing consent, participants were randomly assigned to either the gender-atypical (feminized) or gender-typical (masculinized) adaptation condition. On each trial, participants fist heard an adapting voice followed by a test voice which they judged for attractiveness and masculinity (1 = *Not at all* to 9 = *Extremely*). We also collected perceptions of likability, friendliness, and typicality for future exploratory analyses not reported here. To maintain attention, participants also completed a secondary task rating whether the pitch of each adaptor was higher, lower, or identical to the previous adaptor. In total, participants completed 20 trials in pseudo-randomized order, with each adaptor presented four times.

Hypotheses. Variability in vocal tract length and laryngeal cavity size create large differences in fundamental frequency for male and female voices (Hillenbrand et al., 1995). Perceivers evaluate men and women with regard to these differences, rating men as more attractive when their voices have low fundamental frequency but women as more attractive when their voices have high fundamental frequency (Puts, 2005; Puts, Barndt, Welling, Dawood, & Burriss, 2011). Therefore, we predicted that adaptation to feminized voices would produce contrastive aftereffects, making neutral male test voices sound more gender-typical and therefore more attractive. Conversely, adaptation to masculinized voices should make neutral male test voices sound less gender-typical and therefore less attractive. We also collected measures of perceived likability, friendliness, and typicality for future exploratory analyses not tested here.

Analysis

Load Data

```
data <- read.csv("study2_data.csv", header = TRUE)
```

Factor

```r
# participant ID
data$ID <- factor(data$ID)

# condition
data$condition <- as.factor(data$condition)

# participant sex
data$Sex <- as.factor(data$Sex)
```

Filter
There were only 3 participants who did not identify as male or female. Because we were interested in investigating the interaction between condition and participant sex, we filtered out participants who did not identify as male or female since the power for detecting an effect with a sample size of 3 is too low.

```r
nrow(data)/20  # divide by number of trials since data is long formed
```

```
## [1] 179
```

```r
data <- data %>%
    filter(Sex == "1" | Sex == "2")
nrow(data)/20
```

```
## [1] 175
```

Check Data Quality
Group by participant ID and filter out participants with a response range of 1 on any of the dependent variables.

```r
# sample size before filtering
nrow(data)/20  # divide by number of trials since data is long form
```

```
## [1] 175
```

```r
# attraction
data <- data %>%
    group_by(ID) %>%
    filter((max(attraction) - min(attraction) > 1))

# masculinity
data <- data %>%
    group_by(ID) %>%
    filter((max(masculinity) - min(masculinity) > 1))

# likability
data <- data %>%
    group_by(ID) %>%
    filter((max(likability) - min(likability) > 1))

# friends
data <- data %>%
    group_by(ID) %>%
```

```
    filter((max(friends) - min(friends) > 1))

# typicality
data <- data %>%
    group_by(ID) %>%
    filter((max(typicality) - min(typicality) > 1))

# sample size after filtering
nrow(data)/20
```

```
## [1] 166
```

The original sample size was 175. After filtering participants whose responses did not meet our requirements, the final sample size is 166.

Demographics After filtering participants, calculate the demographics of the final sample.

Sex

```
# 1 = male, 2 = female, 3 = other
table(data$Sex)/20
```

```
##
##   1   2   3
##  30 136   0
```

The majority of the sample is female (81.93%).

Race

```
# 1 = Asian, 2 = Black, 3 = Latino, 4 = White, 5 = Biracial/Other
table(data$Race)/20
```

```
##
##   1   2   3   4   5
##  10  14  17 113  12
```

The majority of the sample is White (68.07%) *Age*

```
stat.desc(data$Age)
```

```
##       nbr.val      nbr.null        nbr.na           min           max
##  3320.0000000     0.0000000     0.0000000    18.0000000    72.0000000
##         range           sum        median          mean       SE.mean
##    54.0000000 84160.0000000    23.0000000    25.3493976     0.1472108
##  CI.mean.0.95           var       std.dev      coef.var
##     0.2886331    71.9477851     8.4822040     0.3346117
```

The average age is 25.35 years old, with a range from 18 - 72.

Multilevel Analyses

The following analyses are done in a step-wise fashion.

Attraction

Main Effect: Attraction by Condition (Atypical/Typical)

```
# reference group = atypical condition
data$condition <- relevel(data$condition, ref = "atypical")

# multilevel model
model.1 <- lmer(attraction ~ condition + (1 | ID) + (1 | trial), data = data,
    na.action = "na.exclude", control = lmerControl(optimizer = "optimx",
        calc.derivs = FALSE, optCtrl = list(method = "nlminb")))
```

```
## Loading required namespace: optimx
```

```
summary(model.1)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: attraction ~ condition + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 13758.6
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.03988 -0.68186  0.02833  0.69512  2.75984
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.0979   1.0478
##  trial    (Intercept) 0.2737   0.5231
##  Residual             3.2805   1.8112
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##                  Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)        5.5655     0.1694  64.8571  32.848 < 0.0000000000000002 ***
## conditiontypical  -0.6466     0.1744 164.0000  -3.708             0.000286 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## condtntypcl -0.508
```

```
# confidence interval
ci.1 <- confint(model.1, method = "Wald", level = 0.95)
ci.1
```

```
##                      2.5 %     97.5 %
```

```
## .sig01                    NA         NA
## .sig02                    NA         NA
## .sigma                    NA         NA
## (Intercept)       5.2333986  5.8975538
## conditiontypical -0.9883759 -0.3047716
```

```
# group means
attraction_condition <- data %>%
    group_by(condition) %>%
    summarise(mean = mean(attraction), sd = sd(attraction), n = n(), se = sd(attraction)/sqrt(n()))
attraction_condition
```

```
## # A tibble: 2 x 5
##   condition  mean    sd     n     se
##   <fct>     <dbl> <dbl> <int>  <dbl>
## 1 atypical   5.57  2.17  1680 0.0531
## 2 typical    4.92  2.13  1640 0.0525
```

Test voices were rated as more attractive after adaptation to feminized voices ($M = 5.57$, $SD = 2.17$) relative to masculinized voices ($M = 4.92$, $SD = 2.13$), $t(164) = -3.71$, $p < .001$.

Main Effect: Attraction by Participant Sex (Male/Female)

```
# reference group = female participants
data$Sex <- relevel(data$Sex, ref = "2")

# multilevel model
model.2 <- lmer(attraction ~ Sex + (1 | ID) + (1 | trial), data = data,
    na.action = "na.exclude", control = lmerControl(optimizer = "optimx",
        calc.derivs = FALSE, optCtrl = list(method = "nlminb")))
summary(model.2)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: attraction ~ Sex + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 13760.5
##
## Scaled residuals:
##      Min       1Q   Median       3Q      Max
## -3.00845 -0.67281  0.03536  0.70415  2.74799
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.1168   1.0568
##  trial    (Intercept) 0.2737   0.5231
##  Residual             3.2805   1.8112
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
```

```
##             Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)   5.1085     0.1520  44.9564  33.610 < 0.0000000000000002 ***
## Sex1          0.7615     0.2283 163.9986   3.336              0.00105 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr)
## Sex1 -0.271
```

```
# confidence interval
ci.2 <- confint(model.2, method = "Wald", level = 0.95)
ci.2
```

```
##                2.5 %   97.5 %
## .sig01            NA       NA
## .sig02            NA       NA
## .sigma            NA       NA
## (Intercept) 4.810558 5.406354
## Sex1        0.314126 1.208962
```

```
# group means
attraction_Sex <- data %>%
    group_by(Sex) %>%
    summarise(mean = mean(attraction), sd = sd(attraction), n = n(), se = sd(attraction)/sqrt(n()))
attraction_Sex
```

```
## # A tibble: 2 x 5
##   Sex    mean    sd     n     se
##   <fct> <dbl> <dbl> <int>  <dbl>
## 1 2      5.11  2.17  2720 0.0416
## 2 1      5.87  2.10   600 0.0856
```

Male participants ($M = 5.87$, $SD = 2.10$) rated test voices as significantly more attractive than female participants ($M = 5.11$, $SD = 2.17$), $t(164) = 3.34$, $p = .001$.

Interaction: Attraction by Condition (Atypical/Typical) and Participant Sex (Male/Female)

```
# multilevel model
model.3 <- lmer(attraction ~ condition * Sex + (1|ID) + (1|trial), data=data, na.action = 'na.exclude',
summary(model.3)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: attraction ~ condition * Sex + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 13746.2
##
## Scaled residuals:
```

```
##      Min       1Q   Median       3Q      Max
## -3.02936 -0.68547  0.03129  0.69776  2.76663
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.0135   1.0067
##  trial    (Intercept) 0.2737   0.5231
##  Residual             3.2805   1.8112
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##                       Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)             5.4846     0.1761  72.9144  31.150 < 0.0000000000000002
## conditiontypical       -0.7522     0.1861 162.0007  -4.042            0.0000817
## Sex1                    0.4248     0.3015 162.0007   1.409                0.161
## conditiontypical:Sex1   0.6678     0.4386 162.0007   1.523                0.130
##
## (Intercept)           ***
## conditiontypical      ***
## Sex1
## conditiontypical:Sex1
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) cndtnt Sex1
## condtntypcl -0.528
## Sex1        -0.326  0.309
## cndtntyp:S1  0.224 -0.424 -0.688
```

```
#confidence interval
ci.3 <- confint(model.3,method="Wald", level=0.95)
ci.3
```

```
##                            2.5 %     97.5 %
## .sig01                        NA         NA
## .sig02                        NA         NA
## .sigma                        NA         NA
## (Intercept)            5.1394731  5.8296445
## conditiontypical      -1.1169549 -0.3874569
## Sex1                  -0.1661447  1.0157771
## conditiontypical:Sex1 -0.1917372  1.5273989
```

```
# group means
attraction_total <- data %>% group_by(condition, Sex) %>%
  summarise(mean = mean(attraction),
            sd = sd(attraction),
            n = n(),
            se = sd(attraction)/sqrt(n()))
```

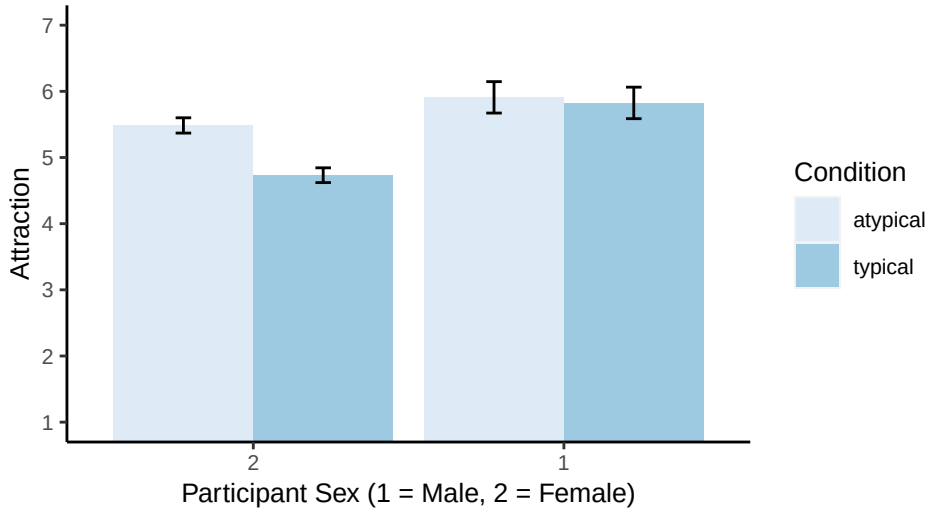
```
## `summarise()` has grouped output by 'condition'. You can override using the `.groups` argument.
```

```
attraction_total
```

```
## # A tibble: 4 x 6
## # Groups:   condition [2]
##   condition Sex    mean    sd     n     se
##   <fct>     <fct> <dbl> <dbl> <int>  <dbl>
## 1 atypical  2      5.48  2.17  1360 0.0589
## 2 atypical  1      5.91  2.16   320 0.121
## 3 typical   2      4.73  2.10  1360 0.0569
## 4 typical   1      5.82  2.03   280 0.121
```

```
#plot with 95% CI
attraction_plot <- data %>%
  group_by(condition, Sex) %>%
  phe_mean(x = attraction, type = "full", confidence = 0.95) %>%
  ggplot(aes(x=Sex, y=value, fill=condition)) +
  geom_bar(stat = "identity", position = "dodge", width = .90) +
  geom_errorbar(aes(ymin = lowercl, ymax = uppercl), position = position_dodge(.90), width = 0.1) +
  scale_y_continuous(limits=c(1,7), breaks=seq(1,7,by=1), oob = rescale_none) +
  scale_fill_brewer(palette = 1) +
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_blank(), axis.line = element_line(colour = "black"),
        text = element_text(size = 10)) + # apply custom minimal theme
  labs(title = "", x="Participant Sex (1 = Male, 2 = Female)", y="Attraction", fill="Condition")

attraction_plot
```



The interaction between condition and participant sex is not significant, $t(162) = 1.52$, p=.130.

Masculinity

Main Effect: Masculinity by Condition

```
model.4 <- lmer(masculinity ~ condition + (1 | ID) + (1 | trial), data = data,
    na.action = "na.exclude", control = lmerControl(optimizer = "optimx",
        calc.derivs = FALSE, optCtrl = list(method = "nlminb")))
summary(model.4)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: masculinity ~ condition + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 12858.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0522 -0.6320  0.0302  0.6474  3.2915
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.9611   0.9803
##  trial    (Intercept) 0.1593   0.3992
##  Residual             2.4890   1.5777
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##                   Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)         5.9119     0.1445  87.0086  40.904 < 0.0000000000000002 ***
## conditiontypical   -0.9747     0.1617 164.0008  -6.026          0.0000000107 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## condtntypcl -0.553
```

```
# confidence interval
ci.4 <- confint(model.4, method = "Wald", level = 0.95)
ci.4
```

```
##                       2.5 %     97.5 %
## .sig01                   NA         NA
## .sig02                   NA         NA
## .sigma                   NA         NA
## (Intercept)       5.628630  6.1951793
## conditiontypical -1.291722 -0.6576974
```

```
# group means
masculinity_condition <- data %>%
    group_by(condition) %>%
    summarise(mean = mean(masculinity), sd = sd(masculinity), n = n(),
        se = sd(masculinity)/sqrt(n()))
masculinity_condition
```

```
## # A tibble: 2 x 5
##   condition  mean    sd     n     se
##   <fct>     <dbl> <dbl> <int>  <dbl>
## 1 atypical   5.91  1.90  1680 0.0463
## 2 typical    4.94  1.89  1640 0.0467
```

Test voices were rated as more masculine after adaptation to feminized voices ($M = 5.91$, $SD = 1.90$) relative to masculinized voices ($M = 4.94$, $SD = 1.89$), $t(164) = -6.03$, $p < .001$.

Main Effect: Masculinity by Participant Sex

```
# reference group = female
data$Sex <- relevel(data$Sex, ref = "2")

# multilevel model
model.5 <- lmer(masculinity ~ Sex + (1 | ID) + (1 | trial), data = data,
    na.action = "na.exclude", control = lmerControl(optimizer = "optimx",
        calc.derivs = FALSE, optCtrl = list(method = "nlminb")))
summary(model.5)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: masculinity ~ Sex + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 12882.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0323 -0.6384  0.0294  0.6424  3.2786
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 1.1400   1.0677
##  trial    (Intercept) 0.1594   0.3992
##  Residual             2.4890   1.5777
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##             Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)   5.3147     0.1314  65.8453  40.447 < 0.0000000000000002 ***
## Sex1          0.6403     0.2268 163.9989   2.823              0.00535 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##      (Intr)
## Sex1 -0.312
```

```
# confidence interval
ci.5 <- confint(model.5, method = "Wald", level = 0.95)
ci.5
```

```
##                 2.5 %   97.5 %
## .sig01             NA       NA
## .sig02             NA       NA
## .sigma             NA       NA
## (Intercept) 5.057166 5.572245
## Sex1        0.195738 1.084850
```

```
# group means
masculinity_Sex <- data %>%
    group_by(Sex) %>%
    summarise(mean = mean(masculinity), sd = sd(masculinity), n = n(),
        se = sd(masculinity)/sqrt(n()))
masculinity_Sex
```

```
## # A tibble: 2 x 5
##   Sex    mean    sd     n     se
##   <fct> <dbl> <dbl> <int>  <dbl>
## 1 2      5.31  1.94  2720 0.0373
## 2 1      5.96  1.93   600 0.0787
```

Male participants ($M = 5.96$, $SD = 1.93$) rated test voices as significantly more masculine than female participants ($M = 5.31$, $SD = 1.94$), $t(164) = 2.82$, $p = .005$.

Interaction: Masculinity by Condition and Participant Sex

```
# multilevel model
model.6 <- lmer(masculinity ~ condition * Sex + (1|ID) + (1|trial), data=data, na.action = 'na.exclude'
summary(model.6)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: masculinity ~ condition * Sex + (1 | ID) + (1 | trial)
##    Data: data
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 12847.7
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0408 -0.6345  0.0325  0.6434  3.3000
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.8974   0.9473
##  trial    (Intercept) 0.1594   0.3992
##  Residual             2.4890   1.5777
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##                       Estimate Std. Error       df t value             Pr(>|t|)
## (Intercept)             5.8632     0.1516  98.0136  38.665 < 0.0000000000000002
## conditiontypical       -1.0971     0.1734 161.9996  -6.328        0.00000000233
```

```
## Sex1                     0.2555     0.2809 161.9996   0.910               0.3643
## conditiontypical:Sex1    0.7462     0.4085 161.9996   1.826               0.0696
##
## (Intercept)           ***
## conditiontypical      ***
## Sex1
## conditiontypical:Sex1 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) cndtnt Sex1
## condtntypcl -0.572
## Sex1        -0.353  0.309
## cndtntyp:S1  0.243 -0.424 -0.688
```

```
#confidence interval
ci.6 <- confint(model.6,method="Wald", level=0.95)
ci.6
```

```
##                              2.5 %     97.5 %
## .sig01                          NA         NA
## .sig02                          NA         NA
## .sigma                          NA         NA
## (Intercept)            5.56602046  6.1604501
## conditiontypical      -1.43683541 -0.7572822
## Sex1                  -0.29498628  0.8060157
## conditiontypical:Sex1 -0.05455211  1.5468840
```

```
# group means
masculinity_total <- data %>% group_by(condition, Sex) %>%
  summarise(mean = mean(masculinity),
            sd = sd(masculinity),
            n = n(),
            se = sd(masculinity)/sqrt(n()))
```

```
## `summarise()` has grouped output by 'condition'. You can override using the `.groups` argument.
```

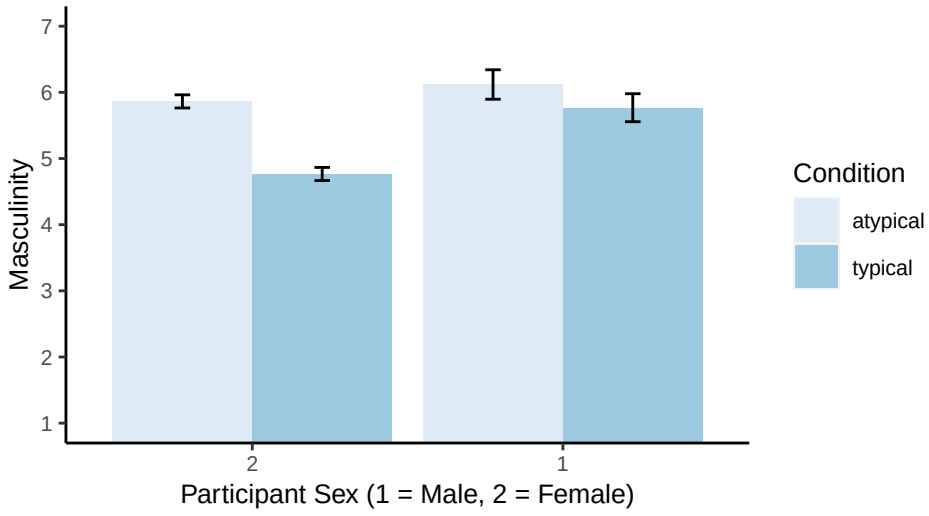
```
masculinity_total
```

```
## # A tibble: 4 x 6
## # Groups:   condition [2]
##   condition Sex    mean    sd     n     se
##   <fct>     <fct> <dbl> <dbl> <int>  <dbl>
## 1 atypical  2      5.86  1.86  1360 0.0505
## 2 atypical  1      6.12  2.02   320 0.113
## 3 typical   2      4.77  1.87  1360 0.0506
## 4 typical   1      5.77  1.80   280 0.107
```

```
#plot with 95% CI
masc_plot <- data %>%
  group_by(condition, Sex) %>%
```

```
  phe_mean(x = masculinity, type = "full", confidence = 0.95) %>%
  ggplot(aes(x=Sex, y=value, fill=condition)) +
  geom_bar(stat = "identity", position = "dodge", width = .90) +
  geom_errorbar(aes(ymin = lowercl, ymax = uppercl), position = position_dodge(.90), width = 0.1) +
  scale_y_continuous(limits=c(1,7), breaks=seq(1,7,by=1), oob = rescale_none) +
  scale_fill_brewer(palette = 1) +
  theme(panel.grid.major = element_blank(), panel.grid.minor = element_blank(),
        panel.background = element_blank(), axis.line = element_line(colour = "black"),
        text = element_text(size = 10)) + # apply custom minimal theme
  labs(title = "", x="Participant Sex (1 = Male, 2 = Female)", y="Masculinity", fill="Condition")

masc_plot
```



The interaction between condition and participant sex is not significant, $t(162) = 1.83$, $p = .070$.

Mediation

Relationship Between Perceived Attractiveness and Masculinity

```
# center masculinity (predictor)
data$masculinity.centered <- as.numeric(scale(data$masculinity, center = TRUE,
    scale = TRUE))

model.7 <- lmer(attraction ~ masculinity + (1 | ID) + (1 | trial), data = data,
    na.action = "na.exclude", control = lmerControl(optimizer = "optimx",
        calc.derivs = FALSE, optCtrl = list(method = "nlminb")))
summary(model.7)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: attraction ~ masculinity + (1 | ID) + (1 | trial)
##    Data: data
```

```
## Control:
## lmerControl(optimizer = "optimx", calc.derivs = FALSE, optCtrl = list(method = "nlminb"))
##
## REML criterion at convergence: 12606.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.2559 -0.5767  0.0231  0.6216  3.8216
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  ID       (Intercept) 0.5395   0.7345
##  trial    (Intercept) 0.2013   0.4486
##  Residual             2.3519   1.5336
## Number of obs: 3320, groups:  ID, 166; trial, 20
##
## Fixed effects:
##               Estimate Std. Error         df t value            Pr(>|t|)
## (Intercept)    1.86306    0.14856   77.40002   12.54 <0.0000000000000002 ***
## masculinity    0.62298    0.01652 3204.64069   37.71 <0.0000000000000002 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## masculinity -0.604
```

```
# confidence interval
ci.7 <- confint(model.7, method = "Wald", level = 0.95)
ci.7
```

```
##                  2.5 %    97.5 %
## .sig01              NA        NA
## .sig02              NA        NA
## .sigma              NA        NA
## (Intercept) 1.5718867 2.1542312
## masculinity 0.5905972 0.6553559
```

Multilevel Mediation - The Effect of Condition on Attractiveness Mediated by Perceived Masculinity

```
# detach lmerTest package (will not run otherwise)
detach("package:lmerTest", unload = TRUE)

# mediator model
med.fit <- lmer(masculinity ~ condition + (1 | ID), data = data)

# outcome model
out.fit <- lmer(attraction ~ condition + masculinity + (1 | ID), data = data)

# function to calculate indirect effect (ACME) and direct effect
```

```r
# (ADE)
med.out <- mediate(med.fit, out.fit, treat = "condition", mediator = "masculinity",
    sims = 1000)
```

```
## Warning in mediate(med.fit, out.fit, treat = "condition", mediator =
## "masculinity", : treatment and control values do not match factor levels; using
## atypical and typical as control and treatment, respectively
```

```r
summary(med.out)
```

```
##
## Causal Mediation Analysis
##
## Quasi-Bayesian Confidence Intervals
##
## Mediator Groups: ID
##
## Outcome Groups: ID
##
## Output Based on Overall Averages Across Groups
##
##                Estimate 95% CI Lower 95% CI Upper             p-value
## ACME            -0.6105      -0.8312        -0.42 <0.0000000000000002 ***
## ADE             -0.0331      -0.2966         0.21                  0.8
## Total Effect    -0.6436      -0.9771        -0.32 <0.0000000000000002 ***
## Prop. Mediated   0.9546       0.6571         1.59 <0.0000000000000002 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Sample Size Used: 3320
##
##
## Simulations: 1000
```

The effect of condition on attraction ratings was fully mediated via perceived masculinity. The indirect effect is -.61 (ACME), which is significant insofar as the confidence interval does not contain zero [-0.80, -0.42].