Hypothesis Tests: Self-Blame and Apology

Analysis Report

2026-01-30

Contents

Setup

Load Libraries

```r
library(dplyr)
library(broom)
```

Define Paths

```r
root       <- "/Users/pei-chin/Research/Behavioral Science and Marketing_data_task"
data_clean <- file.path(root, "data_clean")
output     <- file.path(root, "output")
figures    <- file.path(output, "figures")
```

Load Data

```r
load(file.path(data_clean, "clean_data.RData"))
```

Check Variable Types

```r
str(clean_data$high_blame)
```

```
##  num [1:45] 0 1 0 0 1 0 1 0 0 0 ...
```

```r
str(clean_data$feelings_youalone)
```

```
##  num [1:45] -19 10 -22 -10 -10 -19 -21 -30 -20 -30 ...
```

Hypothesis 1

H1: In the "you apologize alone" scenario, individuals high in self-blame experience higher emotional positivity than those low in self-blame.

Extract Data for Low and High Self-Blame Groups

```r
y0 <- clean_data$feelings_youalone[clean_data$high_blame == 0]
y1 <- clean_data$feelings_youalone[clean_data$high_blame == 1]
```

Quick Data Check

```r
length(y0); length(y1)
```

```
## [1] 35
```

```
## [1] 10
```

```r
sum(is.na(y0)); sum(is.na(y1))
```

```
## [1] 0
```

```
## [1] 0
```

Descriptive Statistics

```r
mean(y0)
```

```
## [1] -20.88571
```

```r
mean(y1)
```

```
## [1] -9.5
```

```r
mean(y1) - mean(y0)
```

```
## [1] 11.38571
```

Welch's t-test

Run Welch's t-test (unequal variances assumed):

```r
tt_H1 <- t.test(y1, y0, var.equal = FALSE)
tt_H1
```

```
##
##  Welch Two Sample t-test
##
## data:  y1 and y0
## t = 2.291, df = 11.448, p-value = 0.04183
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##   0.4993717 22.2720569
## sample estimates:
## mean of x mean of y
##  -9.50000 -20.88571
```

Effect Size Calculation

Calculate effect size using Hedges' g for better small sample correction:

```r
n0 <- length(y0); n1 <- length(y1)
m0 <- mean(y0);   m1 <- mean(y1)
sd0 <- sd(y0);    sd1 <- sd(y1)

# Pooled standard deviation
sp <- sqrt(((n0 - 1)*sd0^2 + (n1 - 1)*sd1^2) / (n0 + n1 - 2))

# Cohen's d
d  <- (m1 - m0) / sp

# Small sample correction factor
J  <- 1 - (3 / (4*(n0 + n1) - 9))

# Hedges' g
g  <- J * d

effect_H1 <- c(
  n_low     = n0,
  n_high    = n1,
  mean_low  = m0,
  mean_high = m1,
```

```
  mean_diff = m1 - m0,
  cohen_d   = d,
  hedges_g  = g
)

effect_H1
```

```
##      n_low     n_high   mean_low  mean_high  mean_diff    cohen_d   hedges_g
##  35.000000  10.000000 -20.885714  -9.500000  11.385714   1.020170   1.002272
```

Save H1 Results

```
H1_summary <- data.frame(
  hypothesis = "H1",
  scenario   = "feelings_youalone",
  n_low      = n0,
  n_high     = n1,
  mean_low   = m0,
  mean_high  = m1,
  mean_diff  = m1 - m0,
  t_value    = as.numeric(tt_H1$statistic),
  df         = as.numeric(tt_H1$parameter),
  p_value    = tt_H1$p.value,
  ci_low     = tt_H1$conf.int[1],
  ci_high    = tt_H1$conf.int[2],
  hedges_g   = g
)

write.csv(
  H1_summary,
  file.path(output, "H1_ttest_hedges_g.csv"),
  row.names = FALSE
)

knitr::kable(H1_summary, digits = 3, caption = "H1 Summary Results")
```

Table 1: H1 Summary Results

hypothesis	scenario	n_low	n_high	mean_low	mean_high	mean_diff	t_value	df	p_value	ci_low	ci_high	hedges_g
H1	feelings_youalone	35	10	-20.886	-9.5	11.386	2.291	11.448	0.042	0.499	22.272	1.002

Exploratory Analysis

Robustness Check Across Scenarios

Test if the pattern holds in other apology scenarios.

```
feeling_vars <- c(
  "feelings_youalone",
  "feelings_bothyoufirst",
```

```
  "feelings_themalone",
  "feelings_boththemfirst",
  "feelings_neither",
  "feelings_youaloneforgiven"
)
```

Helper Function

```
run_welch_effect <- function(data, outcome, group_var = "high_blame") {

  y0 <- data[[outcome]][data[[group_var]] == 0]
  y1 <- data[[outcome]][data[[group_var]] == 1]

  # Remove missing values
  y0 <- na.omit(y0)
  y1 <- na.omit(y1)

  n0 <- length(y0); n1 <- length(y1)
  m0 <- mean(y0);   m1 <- mean(y1)
  sd0 <- sd(y0);    sd1 <- sd(y1)

  # Run the test
  tt <- t.test(y1, y0, var.equal = FALSE)

  # Effect size calculation
  sp <- sqrt(((n0 - 1)*sd0^2 + (n1 - 1)*sd1^2) / (n0 + n1 - 2))
  d  <- (m1 - m0) / sp
  J  <- 1 - (3 / (4*(n0 + n1) - 9))
  g  <- J * d

  # Return a data frame with all the info
  data.frame(
    scenario   = outcome,
    n_low      = n0,
    n_high     = n1,
    mean_low   = m0,
    mean_high  = m1,
    mean_diff  = m1 - m0,
    t_value    = as.numeric(tt$statistic),
    df         = as.numeric(tt$parameter),
    p_value    = tt$p.value,
    ci_low     = tt$conf.int[1],
    ci_high    = tt$conf.int[2],
    hedges_g   = g
  )
}
```

Run Tests Across All Scenarios

```
results_table <- do.call(
  rbind,
  lapply(feeling_vars, function(v) {
    run_welch_effect(clean_data, v)
```

```
  })
)

knitr::kable(results_table, digits = 3, caption = "T-tests Across All Scenarios")
```

Table 2: T-tests Across All Scenarios

scenario	n_low	n_high	mean_low	mean_high	mean_diff	t_value	df	p_value	ci_low	ci_high	hedges_g
feelings_youalone	35	10	-20.886	-9.5	11.386	2.291	11.448	0.042	0.499	22.272	1.002
feelings_bothyoufirst	35	10	6.629	12.1	5.471	1.172	17.160	0.257	-4.375	15.318	0.372
feelings_themalone	35	10	-4.200	-10.2	-6.000	-0.953	13.822	0.357	-19.516	7.516	-0.349
feelings_boththemfirst	35	10	17.543	17.0	-0.543	-0.119	12.834	0.907	-10.417	9.331	-0.046
feelings_neither	35	10	-15.400	-10.8	4.600	0.940	11.565	0.366	-6.104	15.304	0.407
feelings_youaloneforgiven	35	10	-15.657	-7.8	7.857	1.403	14.331	0.182	-4.130	19.844	0.500

Save Exploratory Results

```
write.csv(
  results_table,
  file.path(output, "exploratory_ttests_all_scenarios.csv"),
  row.names = FALSE
)
```

Hypothesis 2

H2: The emotional difference between "other apologizes first" and "self apologizes first" differs by self-blame level (testing for an interaction effect).

Create Difference Score

How much better do people feel when the other person apologizes first?

```
clean_data <- clean_data %>%
  mutate(
    either_first_feeling =
      feelings_boththemfirst - feelings_bothyoufirst
  )
```

T-test on Difference Score

Test if this difference varies by self-blame group:

```
tt_H2 <- t.test(
  either_first_feeling ~ high_blame,
  data = clean_data,
```

```
  var.equal = FALSE
)

tt_H2
```

```
##
##  Welch Two Sample t-test
##
## data:  either_first_feeling by high_blame
## t = 1.2768, df = 16.632, p-value = 0.2192
## alternative hypothesis: true difference in means between group 0 and group 1 is not equal to 0
## 95 percent confidence interval:
##  -3.940791 15.969362
## sample estimates:
## mean in group 0 mean in group 1
##        10.91429         4.90000
```

Effect Size Calculation

```
# Extract difference scores for both groups
diff0 <- clean_data$either_first_feeling[clean_data$high_blame == 0]
diff1 <- clean_data$either_first_feeling[clean_data$high_blame == 1]

# Remove NA values
diff0 <- na.omit(diff0)
diff1 <- na.omit(diff1)

# Calculate descriptive statistics
n0_h2 <- length(diff0)
n1_h2 <- length(diff1)
m0_h2 <- mean(diff0)
m1_h2 <- mean(diff1)
sd0_h2 <- sd(diff0)
sd1_h2 <- sd(diff1)

# Calculate pooled standard deviation
sp_h2 <- sqrt(((n0_h2 - 1)*sd0_h2^2 + (n1_h2 - 1)*sd1_h2^2) / (n0_h2 + n1_h2 - 2))

# Cohen's d
d_h2 <- (m1_h2 - m0_h2) / sp_h2

# Hedges' g (small sample correction)
J_h2 <- 1 - (3 / (4*(n0_h2 + n1_h2) - 9))
g_h2 <- J_h2 * d_h2

cat("Cohen's d:", round(d_h2, 3), "\n")
```

```
## Cohen's d: -0.421
```

```
cat("Hedges' g:", round(g_h2, 3), "\n")
```

```
## Hedges' g: -0.413
```

Save H2 Results

```
H2_summary <- data.frame(
  hypothesis = "H2",
  outcome    = "other_first_minus_self_first",
  n_low      = n0_h2,
  n_high     = n1_h2,
  mean_low   = m0_h2,
  mean_high  = m1_h2,
  mean_diff  = m1_h2 - m0_h2,
  t_value    = as.numeric(tt_H2$statistic),
  df         = as.numeric(tt_H2$parameter),
  p_value    = tt_H2$p.value,
  ci_low     = tt_H2$conf.int[1],
  ci_high    = tt_H2$conf.int[2],
  hedges_g   = g_h2
)

write.csv(
  H2_summary,
  file.path(output, "H2_difference_ttest.csv"),
  row.names = FALSE
)

knitr::kable(H2_summary, digits = 3, caption = "H2 Summary Results")
```

Table 3: H2 Summary Results

hypothesis	outcome	n_low	n_high	mean_low	mean_high	mean_diff	t_value	df	p_value	ci_low	ci_high	hedges_g
H2	other_first_minus_self_first	35	10	10.914	4.9	-6.014	1.277	16.632	0.219	-3.941	15.969	-0.413

Hypothesis 3

H3: People who are more sensitive to the order of apologies feel less emotionally positive even when apologies are mutual, and this pattern differs between high and low self-blame individuals.

Compute Variables

```
clean_data <- clean_data %>%
  mutate(
    mean_mutual = rowMeans(
      cbind(feelings_bothyoufirst, feelings_boththemfirst),
      na.rm = TRUE
    ),
    order_sensitivity =
      abs(feelings_bothyoufirst - feelings_boththemfirst)
  )
```

Regression with Interaction Term

```
model_H3 <- lm(
  mean_mutual ~ order_sensitivity * high_blame,
  data = clean_data
)

summary(model_H3)
```

```
##
## Call:
## lm(formula = mean_mutual ~ order_sensitivity * high_blame, data = clean_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -28.077  -7.231   2.006   8.346  12.663
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   17.0194     2.2813   7.461 3.72e-09 ***
## order_sensitivity             -0.3942     0.1257  -3.136  0.00317 **
## high_blame                     2.5012     4.8232   0.519  0.60684
## order_sensitivity:high_blame  -0.1643     0.3511  -0.468  0.64234
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.772 on 41 degrees of freedom
## Multiple R-squared:  0.244,  Adjusted R-squared:  0.1886
## F-statistic:  4.41 on 3 and 41 DF,  p-value: 0.008881
```

Effect Size Calculation

```
# Get R-squared for full model
r2_full <- summary(model_H3)$r.squared

# Fit model without interaction term
model_H3_no_interaction <- lm(
  mean_mutual ~ order_sensitivity + high_blame,
  data = clean_data
)
r2_no_interaction <- summary(model_H3_no_interaction)$r.squared

# Partial R-squared for interaction
partial_r2_interaction <- r2_full - r2_no_interaction

# Cohen's f for interaction
cohens_f_interaction <- sqrt(partial_r2_interaction / (1 - r2_full))

cat("R² (full model):", round(r2_full, 4), "\n")
```

```
## R² (full model): 0.244
```

```
cat("R² (without interaction):", round(r2_no_interaction, 4), "\n")
```

```
## R² (without interaction): 0.2399
```

```r
cat("Partial R² (interaction):", round(partial_r2_interaction, 4), "\n")
```

```
## Partial R² (interaction): 0.004
```

```r
cat("Cohen's f (interaction):", round(cohens_f_interaction, 4), "\n")
```

```
## Cohen's f (interaction): 0.0731
```

Standardized Coefficients

```r
clean_data_std <- clean_data %>%
  mutate(
    order_sensitivity_std = scale(order_sensitivity)[,1],
    mean_mutual_std = scale(mean_mutual)[,1]
  )

model_H3_std <- lm(
  mean_mutual_std ~ order_sensitivity_std * high_blame,
  data = clean_data_std
)

summary(model_H3_std)
```

```
##
## Call:
## lm(formula = mean_mutual_std ~ order_sensitivity_std * high_blame,
##     data = clean_data_std)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.5880 -0.6665  0.1849  0.7693  1.1672
##
## Coefficients:
##                                  Estimate Std. Error t value Pr(>|t|)
## (Intercept)                      -0.02129    0.15254  -0.140  0.88968
## order_sensitivity_std            -0.45938    0.14650  -3.136  0.00317 **
## high_blame                        0.05324    0.33409   0.159  0.87416
## order_sensitivity_std:high_blame -0.19139    0.40905  -0.468  0.64234
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9008 on 41 degrees of freedom
## Multiple R-squared:  0.244,  Adjusted R-squared:  0.1886
## F-statistic:  4.41 on 3 and 41 DF,  p-value: 0.008881
```

Save H3 Results

```r
H3_coefficients <- tidy(model_H3) %>%
  mutate(
    std_estimate = coef(model_H3_std)
  )

H3_model_fit <- glance(model_H3) %>%
  mutate(
```

```
    partial_r2_interaction = partial_r2_interaction,
    cohens_f_interaction = cohens_f_interaction
  )

write.csv(
  H3_coefficients,
  file.path(output, "H3_regression_coefficients.csv"),
  row.names = FALSE
)

write.csv(
  H3_model_fit,
  file.path(output, "H3_regression_model_fit.csv"),
  row.names = FALSE
)

knitr::kable(H3_coefficients, digits = 3, caption = "H3 Regression Coefficients")
```

Table 4: H3 Regression Coefficients

term	estimate	std.error	statistic	p.value	std_estimate
(Intercept)	17.019	2.281	7.461	0.000	-0.021
order_sensitivity	-0.394	0.126	-3.136	0.003	-0.459
high_blame	2.501	4.823	0.519	0.607	0.053
order_sensitivity:high_blame	-0.164	0.351	-0.468	0.642	-0.191

```
knitr::kable(H3_model_fit, digits = 4, caption = "H3 Model Fit Statistics")
```

Table 5: H3 Model Fit Statistics

r.squared	adj.r.squared	sigma	statistic	p.value	df	logLik	AIC	BIC	deviance	df.residual	nobs	partial_r2_interaction	cohens_f_interaction
0.244	0.1886	9.7721	4.4101	0.0089	3	-164.3368	338.6736	347.7068	3915.285	41	45	0.004	0.0731

Summary

Effect Sizes for All Hypotheses

```
effect_size_summary <- data.frame(
  hypothesis = c("H1", "H2", "H3"),
  effect_type = c("Hedges' g", "Hedges' g", "Cohen's f (interaction)"),
  effect_size = c(g, g_h2, cohens_f_interaction),
  interpretation = c(
    ifelse(abs(g) < 0.2, "negligible",
           ifelse(abs(g) < 0.5, "small",
                  ifelse(abs(g) < 0.8, "medium", "large"))),
    ifelse(abs(g_h2) < 0.2, "negligible",
           ifelse(abs(g_h2) < 0.5, "small",
                  ifelse(abs(g_h2) < 0.8, "medium", "large"))),
```

```
    ifelse(abs(cohens_f_interaction) < 0.1, "small",
           ifelse(abs(cohens_f_interaction) < 0.25, "medium", "large"))
  )
)

write.csv(
  effect_size_summary,
  file.path(output, "all_hypotheses_effect_sizes.csv"),
  row.names = FALSE
)

knitr::kable(effect_size_summary, digits = 3, caption = "Effect Size Summary for All Hypotheses")
```

Table 6: Effect Size Summary for All Hypotheses

hypothesis	effect_type	effect_size	interpretation
H1	Hedges' g	1.002	large
H2	Hedges' g	-0.413	small
H3	Cohen's f (interaction)	0.073	small

Session Information

```
sessionInfo()
```

```
## R version 4.4.2 (2024-10-31)
## Platform: aarch64-apple-darwin20
## Running under: macOS 26.2
##
## Matrix products: default
## BLAS:   /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRblas.0.dylib
## LAPACK: /Library/Frameworks/R.framework/Versions/4.4-arm64/Resources/lib/libRlapack.dylib;  LAPACK v
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/Chicago
## tzcode source: internal
##
## attached base packages:
## [1] stats     graphics  grDevices utils     datasets  methods   base
##
## other attached packages:
## [1] broom_1.0.7 dplyr_1.1.4
##
## loaded via a namespace (and not attached):
##  [1] backports_1.5.0   digest_0.6.37     tidyr_1.3.1       R6_2.5.1
##  [5] fastmap_1.2.0     tidyselect_1.2.1  xfun_0.49         magrittr_2.0.3
##  [9] glue_1.8.0        tibble_3.2.1      knitr_1.49        pkgconfig_2.0.3
## [13] htmltools_0.5.8.1 rmarkdown_2.29    generics_0.1.3    lifecycle_1.0.4
## [17] cli_3.6.3         vctrs_0.6.5       compiler_4.4.2    purrr_1.0.2
```

```
## [21] rstudioapi_0.17.1 tools_4.4.2       pillar_1.10.0     evaluate_1.0.1
## [25] yaml_2.3.10       rlang_1.1.4
```