Lab 04: Contrasts

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**Task 1: Descriptive Statistics**

Table 1

*Table of Descriptive Statistics for the Changes in Depression (one month follow-up minus baseline CES-D scores) in Four Treatment Groups*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  | 95% C.I. | |
| Variables | *M* | *SE* | *df* | *LL* | *UL* |
| Treatments |  |  |  |  |  |
| SS | -2.79 | 1.66 | 135 | -6.07 | 0.49 |
| TGT | -3.02 | 1.36 | 135 | -5.72 | -0.33 |
| GV | -4.50 | 1.63 | 135 | -7.72 | -1.28 |
| REM | -2.14 | 1.47 | 135 | -5.04 | 0.77 |

*Note. REM = recall early memories (control group), SS = signature strengths, TGT = three good things, GV = gratitude visits.*

The confidence interval formula for the estimated change of the CES-D score for Signature Strengths (SS) group is , which verifies that the output from the emmeans package is correct.

**Task 2: Testing a Single Factor Level Mean**

Test if the change of CES-D score is different from zero for the SS intervention.

*H0: µ1 = 0*

*H1: µ1 ≠ 0*

The t-score of the estimated change of CES-D score for the SS intervention is , of which the corresponding two-sided p-value is .095 > .05. Therefore, there was no significant change of CES-D score for the SS intervention, *t*(135) = 1.7, *p* = .097, despite the average change score in this group is negative (*M* = 55, *SE* = 1.66). The output, Table 2, of the test() function in the emmeans package verified the finding above.

Table 2

*Summary for the Changes in Depression (one month follow-up minus baseline CES-D scores) in Four Treatment Groups*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | *M* | *SE* | *t(*135*)* | *p* |
| Treatments |  |  |  |  |
| SS | -2.79 | 1.66 | -1.684 | 0.094 |
| TGT | -3.02 | 1.36 | -2.220 | 0.028\* |
| GV | -4.50 | 1.63 | -2.760 | 0.007\*\* |
| REM | -2.14 | 1.47 | -1.454 | 0.148 |

*Note. REM = recall early memories (control group), SS = signature strengths, TGT = three good things, GV = gratitude visits*

\**p < .05. \*\*p < .01.*

**Task 3: Pairwise Differences**

Test if the change of CES-D score is different between the SS intervention and the TGT intervention.

*H0: µ1 = µ2*

*H1: µ1 ≠ µ2*

The t-score of the estimated difference of CES-D score between the SS intervention and the TGT intervention is , of which the corresponding two-sided p-value is .915 > .05. Therefore, there was no significant difference of CES-D score between the SS intervention and the TGT intervention, *t*(135) = 0.11, *p* = .915. The output, Table 3, of the pairs() function in the emmeans package verified this finding.

Table 3

*Pairwise Differences of Changes in Depression (one month follow-up minus baseline CES-D scores) in Four Treatment Groups*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variables | *M* | *SD* | *t(*135*)* | *p* |
| Treatments |  |  |  |  |
| SS – TGT | 0.230 | 2.15 | 0.107 | 0.915 |
| SS – GV | 1.707 | 2.33 | 0.734 | 0.464 |
| TGT – GV | 1.477 | 2.12 | 0.695 | 0.488 |
| REM – SS | 0.658 | 2.21 | 0.297 | 0.767 |
| REM – TGT | 0.888 | 2.00 | 0.444 | 0.658 |
| REM – GV | 2.365 | 2.19 | 1.078 | 0.283 |

*Note. REM = recall early memories (control group), SS = signature strengths, TGT = three good things, GV = gratitude visits*

\**p < .05. \*\*p < .01.*

**Task 4: Linear Contrasts**

Test if the three experimental interventions decreased the depression more than the control intervention. Let *L* be the following linear contrast:

*L = 1/3\* µ1+1/3\* µ2+1/3\* µ3 - µ4*

The hypotheses:

*H0: L ≥ 0*

*H1: L < 0*

The t-score of the estimated difference of CES-D score between the three experimental groups and the control group is , of which the corresponding one-sided p-value is .225 > .05. Therefore, there was no significant difference of CES-D score between the three experimental groups and the control group, *t*(135) = -0.76, *p* = .225. The following output of the contrast() function in the emmeans package verified this finding.

contrast

c(0.333333333333333, 0.333333333333333, 0.333333333333333, -1

estimate SE df t.ratio p.value

-1.3 1.72 135 -0.757 0.4501

**Task 5: Linear Contrasts (Cont.)**

Test if two experimental interventions, TGT and GV, decreased the depression more than the control intervention. Let *L* be the following linear contrast:

*L = 0\* µ1+1/2\* µ2+1/2\* µ3 - µ4*

The hypotheses:

*H0: L ≥ 0*

*H1: L < 0*

According to the following output of the contrast() function in the emmeans package, the t-score of the estimated difference of CES-D score between the two experimental groups and the control group is , of which the corresponding one-sided p-value is .742 > .05. Therefore, there was no significant difference of CES-D score between the three experimental groups and the control group, *t*(135) = -0.90, *p* = .742. The following output of the contrast() function in the emmeans package verified this finding.

contrast estimate SE df t.ratio p.value

c(0, 0.5, 0.5, -1) -1.63 1.81 135 -0.898 0.3710

Appendix

*R codes for Lab 04*

# Task 01: Descriptive Statistics

```{r}

library(emmeans)

rct\_wide$cesdGS <- rct\_wide$cesdTotal.3 - rct\_wide$cesdTotal.0 # calculate the change score

lm2 <- lm(formula = cesdGS ~ int\_fact, data = rct\_wide) # fit the linear model

emm2 <- emmeans(object=lm2, specs=~int\_fact) # calculate marginal means

s.emm2 <- summary(emm2) # get the summary table of the marginal means

s.emm2

m.SS <- s.emm2$emmean[which(s.emm2$int\_fact=="SS")] # Mean(SS)

se.SS <- s.emm2$SE[which(s.emm2$int\_fact=="SS")] # SE(SS)

t.135 <- qt(p=0.975, df=135, lower.tail = TRUE) # two-sided t-test, crit. value, df = 135, alpha=.05

m.SS+t.135\*se.SS # UL of the 95% C.I. = Mean(SS) + t(135)\*SE(SS)

m.SS-t.135\*se.SS # LL of the 95% C.I. = Mean(SS) - t(135)\*SE(SS)

```

# Task 02: Test a Single Factor Level Mean

```{r}

t.SS <- (m.SS-0)/se.SS # calculate t-score of SS = (Mean(SS)-0)/SE(SS)

2\*pt(q = t.SS, df = 135, lower.tail = TRUE)# get p-value for two-sided t-test

test(object=emm2,side="!=") # two-sided t-tests for every group

```

# Task 03: Testing Pairwise Comparisons

```{r}

m.TGT <- s.emm2$emmean[which(s.emm2$int\_fact=="TGT")] # Mean(TGT)

se.TGT <- s.emm2$SE[which(s.emm2$int\_fact=="TGT")] # SE(TGT)

se.SS.TGT <- (se.SS^2+se.TGT^2)^0.5 # sd(SS-TGT)=(SE(SS)^2+SE(TGT)^2)^0.5

t.SS.TGT <- (m.SS-m.TGT-0)/se.SS.TGT # t-score of the CES-D change score difference between SS and TGT

2\*pt(q=t.SS.TGT, df=135, lower.tail = FALSE) # p-value of the difference score

pairs(emm2,adjust="none") # pairwise comparison

```

# Task 04 Testing Linear Contrasts

```{r}

m.GV <- s.emm2$emmean[which(s.emm2$int\_fact=="GV")] # Mean(GV)

m.REM <- s.emm2$emmean[which(s.emm2$int\_fact=="REM")] # Mean(REM)

se.GV <- s.emm2$SE[which(s.emm2$int\_fact=="GV")] # SE(GV)

se.REM <- s.emm2$SE[which(s.emm2$int\_fact=="REM")] # SE(REM)

t.con <- (1/3\*(m.SS+m.TGT+m.GV)-m.REM)/(1/9\*(se.SS^2+se.TGT^2+se.GV^2)+se.REM^2)^0.5 # t-score of the linear contrast

pt(q=t.con, df=135, lower.tail = TRUE) # p-value of the linear contrast

contrast(emm2, method=list(c(1/3,1/3,1/3,-1)))

```

# Task 05 Testing Linear Contrasts (Cont.)

```{r}

contrast(emm2, method=list(c(0,1/2,1/2,-1)))

```