Does learning a skill with the expectation of teaching it impair the skill's execution under psychological pressure if the skill is learned with analogy instructions?

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Libraries needed.

```
library(mvnormtest)
library(reshape2)
library(ggplot2)
library(stringr)
library(ez)
library(afex)
library(jtools)
library(e1071)
library(dplyr)
library(janitor)
library(Cronbach)
library(rstatix)
library(DescTools)
library(effectsize)
```

Statistical Analyses and Results Reported in Article

Uploading datasets.

These datasets can be found at https://osf.io/vpr92/. Download the files and change the directory accordingly.

```
data_for_statistical_analyses = read.csv("C:/Users/Daniel Aranha Cabral/Box/PEP lab/Teach analogy study/Teach a
nalogy - final datasets/Teach analogy dataset/Data for Statistical Analyses.csv")

item_level_questionnaire_data = read.csv("C:/Users/Daniel Aranha Cabral/Box/PEP lab/Teach analogy study/Teach a
nalogy - final datasets/Teach analogy dataset/Item-Level Questionnaire Data.csv")
```

Separating the anxiety dataset into raw high- and low-pressure posttest scores, and creating a long-format dataset to use in the ANOVA.

```
anxiety_raw_hp = data.frame(item_level_questionnaire_data[, (colnames(item_level_questionnaire_data) %in% c("ID
", "Group", "Expectation", "Instruction", 'RCSI2_HP_Q1', 'RCSI2_HP_Q2', 'RCSI2_HP_Q3', 'RCSI2_HP_Q4', 'RCSI2_HP
_Q5', 'RCSI2_HP_Q6', 'RCSI2_HP_Q7',
                                                                                                         'RCSI2
_HP_Q8','RCSI2_HP_Q9','RCSI2_HP_Q10','RCSI2_HP_Q11','RCSI2_HP_Q12','RCSI2_HP_Q13', 'RCSI2_HP_Q14',
                                                                                                         'RCSI2
_HP_Q15','RCSI2_HP_Q16', 'RCSI2_HP_Q17'))])

anxiety_raw_lp = data.frame(item_level_questionnaire_data[, (colnames(item_level_questionnaire_data) %in% c("ID
", "Group", "Expectation", "Instruction", 'RCSI2_LP_Q1', 'RCSI2_LP_Q2', 'RCSI2_LP_Q3', 'RCSI2_LP_Q4', 'RCSI2_LP
_Q5', 'RCSI2_LP_Q6', 'RCSI2_LP_Q7',
                                                                                                         'RCSI2
_LP_Q8','RCSI2_LP_Q9','RCSI2_LP_Q10','RCSI2_LP_Q11','RCSI2_LP_Q12','RCSI2_LP_Q13', 'RCSI2_LP_Q14',
                                                                                                         'RCSI2
_LP_Q15','RCSI2_LP_Q16', 'RCSI2_LP_Q17'))])

anxiety_subscales_long = subset(data_for_statistical_analyses, select = c(1,6,7,8,23,24,25,26,27,28))
anxiety_subscales_long_aov = melt(anxiety_subscales_long, id.vars = c("ID","Group", "Expectation", "Instruction
s", "Cognitive_hp", "Cognitive_lp", "Somatic_hp", "Somatic_lp"))
names(anxiety_subscales_long_aov)[names(anxiety_subscales_long_aov) == "variable"] <- "Condition"
names(anxiety_subscales_long_aov)[names(anxiety_subscales_long_aov) == "value"] <- "Average_anxiety"

anxiety_subscales_long_aov$Condition = anxiety_subscales_long_aov$Condition = gsub("Average_anxiety_lp", "LP",
anxiety_subscales_long_aov$Condition)
anxiety_subscales_long_aov$Condition = anxiety_subscales_long_aov$Condition = gsub("Average_anxiety_hp", "HP",
anxiety_subscales_long_aov$Condition)
```

Creating a new dataset for free recall.

```
free_recall = subset(data_for_statistical_analyses, select = c(1, 6,7,8, 22,21))
free_recall = na.omit(free_recall)
```

Processing the performance datasets.

```
posttest_wide = subset(data_for_statistical_analyses, select = c(1,6,7,8,9,13,14,15,19,20,36))

posttest_long = melt(posttest_wide, id.vars=c("ID", "Expectation", "Instructions", "Group", "BVE_pt", "BVE_lp",
"BVE_hp", "Radial.Error_pt", "Did.not.fol.rule"))
names(posttest_long)[names(posttest_long) == "variable"] <- "Condition"
names(posttest_long)[names(posttest_long) == "value"] <- "Radial.Error"
names(posttest_long)[names(posttest_long) == "BVE_pt"] <- "BVE_av"
```

```
posttest_long$Condition = posttest_long$Condition = gsub("Radial.Error_lp", "LP", posttest_long$Condition)
posttest_long$Condition = posttest_long$Condition = gsub("Radial.Error_hp", "HP", posttest_long$Condition)

pretest = subset(data_for_statistical_analyses, select = c(1,6,7,8,9))

practice = subset(data_for_statistical_analyses, select = c(1,6,7,8,9,10,11,12))

practice_long = melt(practice, id.vars=c("ID", "Expectation", "Instructions", "Group", "Radial.Error_pt"))

names(practice_long)[names(practice_long) == "variable"] <- "Condition"
names(practice_long)[names(practice_long) == "value"] <- "Radial.Error"

practice_long$Condition = practice_long$Condition = gsub("Radial.Error_b1", "Block 1", practice_long$Condition)
practice_long$Condition = practice_long$Condition = gsub("Radial.Error_b3", "Block 3", practice_long$Condition)
practice_long$Condition = practice_long$Condition = gsub("Radial.Error_b6", "Block 6", practice_long$Condition)
```

Creating z-scores for low- and high-pressure posttest radial error. Participants with a z-score ≥ 3 will be excluded.

```
posttest_wide$z_RE_low = (posttest_wide$Radial.Error_lp - mean(posttest_wide$Radial.Error_lp)) / sd(posttest_wi
de$Radial.Error_lp)
posttest_wide$z_RE_high = (posttest_wide$Radial.Error_hp - mean(posttest_wide$Radial.Error_hp)) / sd(posttest_w
ide$Radial.Error_hp)
```

Creating a new dataset with all conditions included.

```
posttest_long2 = subset(posttest_long, select = c(1,2,3,4,5,9,10))

for_plot_pretest = subset(pretest, select = c(1,2,5))
for_plot_pretest$Condition = rep("pt", each = 156)
names(for_plot_pretest)[names(for_plot_pretest) == "Radial.Error_pt"] <- "Radial.Error"

for_plot_practice = subset(practice_long, select = c(1,4, 6,7))
for_plot_posttest = subset(posttest_long, select = c(1, 4, 10,11))

performance_all = rbind(for_plot_pretest, for_plot_practice, for_plot_posttest)
performance_all = na.omit(performance_all)
```

Participants 30, 72, 136 and 157 will be deleted from all datasets.

```
posttest_wide_supplement = posttest_wide

posttest_long_supplement = posttest_long

practice_long_bve = practice_long

performance_all_woutliers = performance_all

performance_all_did_not_fol_rule = performance_all

performance_all = subset(performance_all, ID != 72 & ID != 157 & ID != 30 & ID != 136)

pretest = subset(pretest, ID != 72 & ID != 157 & ID != 30 & ID != 136)

practice = subset(practice, ID != 72 & ID != 157 & ID != 30 & ID != 136)

practice_long = subset(practice_long, ID != 72 & ID != 157 & ID != 30 & ID != 136)

posttest_long = subset(posttest_long, ID != 72 & ID != 157 & ID != 30 & ID != 136)

posttest_wide = subset(posttest_wide, ID != 72 & ID != 157 & ID != 30 & ID != 136)
```

Changing group and condition names.

```
performance_all$Condition = performance_all$Condition = gsub("hp", "HP", performance_all$Condition)
performance_all$Condition = performance_all$Condition = gsub("lp", "LP", performance_all$Condition)
performance_all$Condition = performance_all$Condition = gsub("b1", "Block 1", performance_all$Condition)
performance_all$Condition = performance_all$Condition = gsub("b3", "Block 3", performance_all$Condition)
performance_all$Condition = performance_all$Condition = gsub("b6", "Block 6", performance_all$Condition)
performance_all$Condition = performance_all$Condition = gsub("pt", "Pretest", performance_all$Condition)
performance_all$Group = performance_all$Group = gsub("TTA", "Test/Analogy", performance_all$Group)
performance_all$Group = performance_all$Group = gsub("TTE", "Test/Explicit", performance_all$Group)
performance_all$Group = performance_all$Group = gsub("TCA", "Teach/Analogy", performance_all$Group)
performance_all$Group = performance_all$Group = gsub("TCE", "Teach/Explict", performance_all$Group)
```

Demographics data.

```
demographics = subset(data_for_statistical_analyses, select = c(1,2,3,4,5,6))
demographics = subset(demographics, ID != 30 & ID != 72 & ID != 136 & ID != 157)

age = data.frame(aggregate(Age ~ Group, demographics, function(x) c(mean = mean(x), sd = sd(x))))
golf_life =data.frame(aggregate(Golf_life ~ Group, demographics, function(x) c(mean = mean(x), sd = sd(x))))
```

```r
golf_year = data.frame(aggregate(Golf_year ~ Group, demographics, function(x) c(mean = mean(x), sd = sd(x))))

age_golflife = merge(age, golf_life, golf_year, by.x = "Group", by.y = "Group")
demographics_mean_ci = merge(age_golflife, golf_year, by.x =  "Group")
demographics_mean_ci = data.frame(t(demographics_mean_ci))
names(demographics_mean_ci)[names(demographics_mean_ci) == "X1"] <- "TCA"
names(demographics_mean_ci)[names(demographics_mean_ci) == "X2"] <- "TCE"
names(demographics_mean_ci)[names(demographics_mean_ci) == "X3"] <- "TTA"
names(demographics_mean_ci)[names(demographics_mean_ci) == "X4"] <- "TTE"
demographics_mean_ci = demographics_mean_ci[-c(1),]

gender = data.frame(tabyl(demographics, Sex, Group))

print(demographics_mean_ci)
```

```
##                      TCA       TCE       TTA       TTE
## Age.mean       20.815789 20.692308 21.473684 20.594595
## Age.sd          1.783638  1.837530  2.688683  2.127328
## Golf_life.mean 1.5526316 1.6153846 1.6315789 1.4324324
## Golf_life.sd   0.7604184 0.7474654 0.7505332 0.6472395
## Golf_year.mean 0.7368421 0.8205128 0.7368421 0.6216216
## Golf_year.sd   0.4462583 0.5063697 0.6010896 0.4916724
```

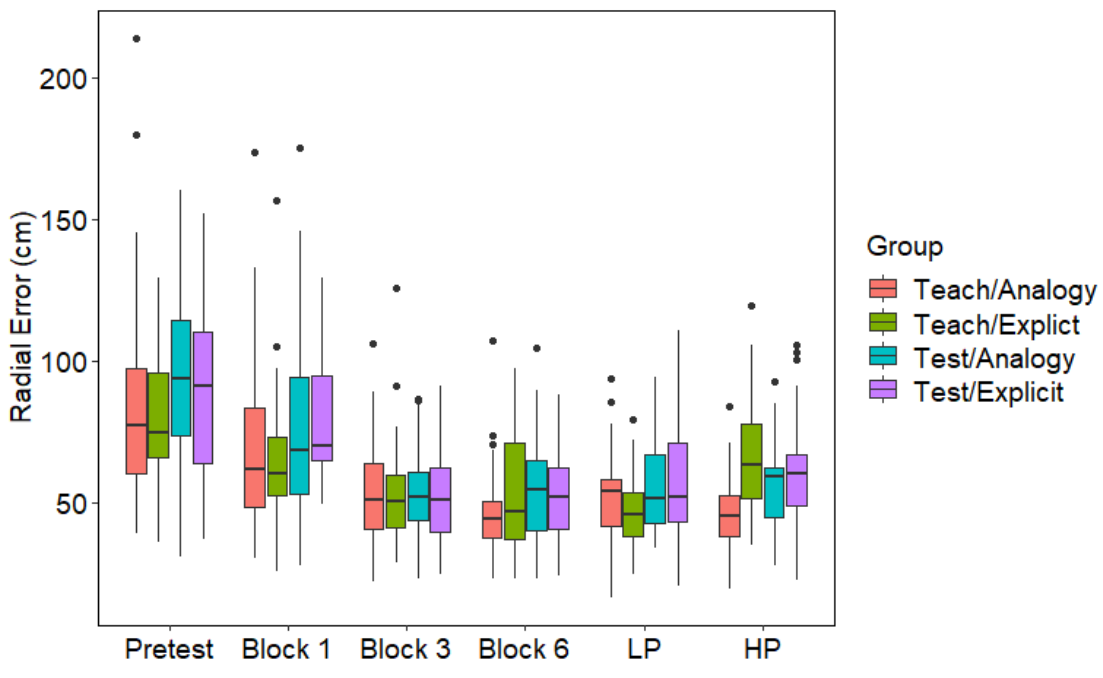
```r
print(gender)
```

```
##   Sex TCA TCE TTA TTE
## 1   F  21  24  21  24
## 2   M  17  15  17  13
```

Radial error analysis.

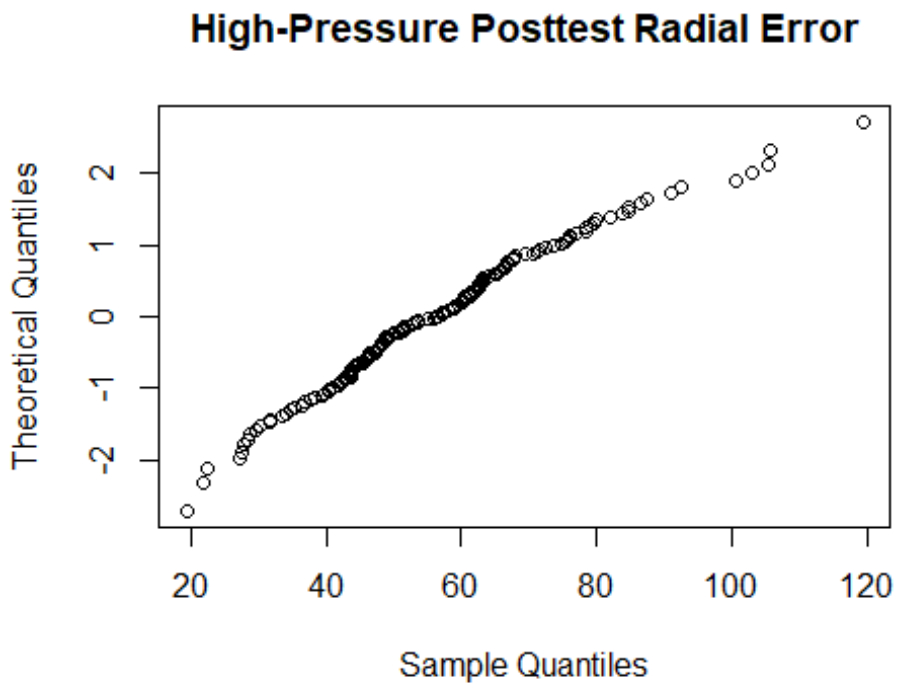
Plotting radial error as a function of study phase and group.

```r
performance_all$Condition=factor(performance_all$Condition, levels = c("Pretest", "Block 1", "Block 3","Block 6
", "LP","HP"))

ggplot(performance_all, aes(x = Condition, y = Radial.Error, fill = Group)) +
  geom_boxplot() +theme(axis.text.x = element_text(angle = 90), legend.position = "right")+
  theme_classic()+ labs(x = ' ') + scale_x_discrete(limits = c('Pretest', "Block 1", "Block 3", "Block 6", 'LP'
, 'HP'))+
  labs(y = "Radial Error (cm)") +
  theme(axis.text.x = element_text(size = 14, color = "black"),
        axis.title.y = element_text(size = 14, color = "black"),
        axis.text.y = element_text(size = 14, color = "black"))+
  theme(legend.text = element_text(size = 14)) + theme(legend.title = element_text(size = 14))+
  theme(panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=.5))
```

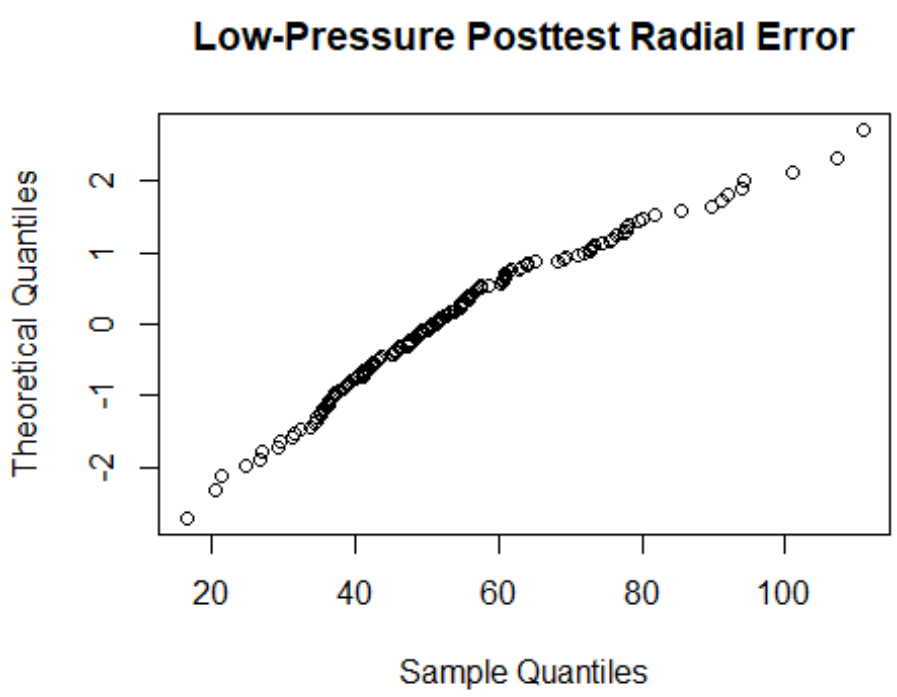


Q-Q plots for radial error for high- and low-pressure posttests.

```r
qqnorm(posttest_wide$Radial.Error_hp, datax = T, main = "High-Pressure Posttest Radial Error")
```




```
qqnorm(posttest_wide$Radial.Error_lp, datax = T, main = "Low-Pressure Posttest Radial Error")
```



Shapiro-Wilk test for both high- and low-pressure posttests.

```
shapiro.test(posttest_wide$Radial.Error_hp)

##
##  Shapiro-Wilk normality test
##
## data:  posttest_wide$Radial.Error_hp
## W = 0.97398, p-value = 0.005558
```

```
shapiro.test(posttest_wide$Radial.Error_lp)

##
##  Shapiro-Wilk normality test
##
## data:  posttest_wide$Radial.Error_lp
## W = 0.95613, p-value = 9.817e-05
```

Skewness and kurtosis for the high-pressure posttest.

```
skewness(posttest_wide$Radial.Error_hp, type = 2)

## [1] 0.6330244

kurtosis(posttest_wide$Radial.Error_hp, type = 2)

## [1] 0.8145795
```

Skewness and kurtosis for the low-pressure posttest.

```
skewness(posttest_wide$Radial.Error_lp, type = 2)

## [1] 0.8330743

kurtosis(posttest_wide$Radial.Error_lp, type = 2)

## [1] 0.8814489
```

2 (Expectation) x 2 (Instructions) ANOVA with pretest radial error serving as the dependent variable.

```
pretest_result = aov_ez(id = "ID", dv = "Radial.Error_pt", between = c("Expectation", "Instructions"), data = p
retest, anova_table = list(es = "pes"))
knitr::kable(nice(pretest_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 148	921.81	2.19	.015	.141
Instructions	1, 148	921.81	0.97	.006	.327
Expectation:Instructions	1, 148	921.81	0.00	<.001	.961

Since the main effect of expectation was η2p ≥ .0099, we included pretest radial error as a covariate in the analyses.

2 (Expectation) x 2 (Instructions) x 2 (Posttest) mixed-factor ANCOVA with repeated-measures on the last factor, posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
posttest_result = aov_ez(id = "ID", dv = "Radial.Error", data =  posttest_long, between=c("Expectation", "Instr
uctions"), within=c("Condition"), covariate = "Radial.Error_pt", factorize = F,  anova_table = list(es = "pes")
)

knitr::kable(nice(posttest_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	329.58	4.05 *	.027	.046
Instructions	1, 147	329.58	6.87 **	.045	.010
Radial.Error_pt	1, 147	329.58	4.73 *	.031	.031
Expectation:Instructions	1, 147	329.58	0.78	.005	.377
Condition	1, 147	222.93	0.47	.003	.493
Expectation:Condition	1, 147	222.93	1.91	.013	.170
Instructions:Condition	1, 147	222.93	18.25 ***	.110	<.001
Radial.Error_pt:Condition	1, 147	222.93	0.00	<.001	.960
Expectation:Instructions:Condition	1, 147	222.93	8.62 **	.055	.004

Because the three-way interaction was statistically significant, we followed it up with separate ANCOVAs for low- and high-pressure posttests.

2 (Expectation) x 2 (Instructions) ANCOVA with low-pressure posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
low_pressure = subset(posttest_long, Condition == "LP")

low_aov = aov_ez("ID", "Radial.Error", low_pressure, between=c("Expectation", "Instructions"), covariate = "Rad
ial.Error_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(low_aov))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	285.03	5.72 *	.037	.018
Instructions	1, 147	285.03	0.46	.003	.499
Radial.Error_pt	1, 147	285.03	2.84 +	.019	.094
Expectation:Instructions	1, 147	285.03	1.35	.009	.247

2 (Expectation) x 2 (Instructions) ANCOVA with high-pressure posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
high_pressure = subset(posttest_long, Condition == "HP")

high_aov = aov_ez("ID", "Radial.Error", high_pressure, between=c("Expectation", "Instructions"), covariate = "R
adial.Error_pt", factorize = F,  anova_table = list(es = "pes"))
knitr::kable(nice(high_aov))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	267.48	0.47	.003	.493
Instructions	1, 147	267.48	23.19 ***	.136	<.001
Radial.Error_pt	1, 147	267.48	2.80 +	.019	.096
Expectation:Instructions	1, 147	267.48	6.71 *	.044	.011

Because the two-way interaction was statistically significant, we followed it up with separate univariate (expectation) ANCOVAs for analogy and explicit instructions groups.

Univariate ANCOVAs (expectation) for the analogy and explicit instructions groups with high-pressure posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
analogy_high = subset(high_pressure, Instructions == 'Analogy')
explicit_high = subset(high_pressure, Instructions == 'Explicit')
```

```
high_analogy = aov_ez("ID", "Radial.Error", analogy_high, between="Expectation", covariate = "Radial.Error_pt", factorize = F,  anova_table = list(es = "pes"))

knitr::kable(nice(high_analogy))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 73	201.82	6.98 *	.087	.010
Radial.Error_pt	1, 73	201.82	2.79 +	.037	.099

```
high_explicit = aov_ez("ID", "Radial.Error", explicit_high, between="Expectation", covariate = "Radial.Error_pt", factorize = F,  anova_table = list(es = "pes"))

knitr::kable(nice(high_explicit))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 73	336.63	1.35	.018	.249
Radial.Error_pt	1, 73	336.63	0.59	.008	.443

Testing homogeneity of regression slopes assumption for 2 (Expectation) x 2 (Instructions) x 2 (Posttest) ANCOVA.

```
ancova_assume_prime_result <- aov_ez("ID", "Radial.Error", posttest_long, between=c("Expectation", "Instructions", "Radial.Error_pt"), within=c("Condition"), factorize = FALSE, anova_table = list(es = "pes"))

knitr::kable(nice(ancova_assume_prime_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 144	333.88	0.03	<.001	.865
Instructions	1, 144	333.88	0.17	.001	.684
Radial.Error_pt	1, 144	333.88	5.39 *	.036	.022
Expectation:Instructions	1, 144	333.88	0.10	<.001	.753
Expectation:Radial.Error_pt	1, 144	333.88	0.21	.001	.646
Instructions:Radial.Error_pt	1, 144	333.88	0.22	.002	.637
Expectation:Instructions:Radial.Error_pt	1, 144	333.88	0.40	.003	.530
Condition	1, 144	220.28	0.46	.003	.498
Expectation:Condition	1, 144	220.28	0.14	.001	.705
Instructions:Condition	1, 144	220.28	5.55 *	.037	.020
Radial.Error_pt:Condition	1, 144	220.28	0.00	<.001	.965
Expectation:Instructions:Condition	1, 144	220.28	0.71	.005	.401
Expectation:Radial.Error_pt:Condition	1, 144	220.28	0.83	.006	.363
Instructions:Radial.Error_pt:Condition	1, 144	220.28	0.92	.006	.339
Expectation:Instructions:Radial.Error_pt:Condition	1, 144	220.28	3.42 +	.023	.066

Testing homogeneity of regression slopes assumption for 2 (Expectation) x 2 (Instructions) ANCOVA for low-pressure posttest.

```
ancova_assume_lp_result <- aov_ez("ID", "Radial.Error", low_pressure, between=c("Expectation", "Instructions", "Radial.Error_pt"),factorize = FALSE, anova_table = list(es = "pes"))

knitr::kable(nice(ancova_assume_lp_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 144	286.52	0.01	<.001	.916
Instructions	1, 144	286.52	1.32	.009	.252
Radial.Error_pt	1, 144	286.52	3.24 +	.022	.074
Expectation:Instructions	1, 144	286.52	0.08	<.001	.778
Expectation:Radial.Error_pt	1, 144	286.52	0.84	.006	.360
Instructions:Radial.Error_pt	1, 144	286.52	0.91	.006	.341
Expectation:Instructions:Radial.Error_pt	1, 144	286.52	0.44	.003	.507

Testing homogeneity of regression slopes assumption for 2 (Expectation) x 2 (Instructions) ANCOVA for high-pressure posttest.

```
ancova_assume_hp_result <- aov_ez("ID", "Radial.Error", high_pressure, between=c("Expectation", "Instructions", "Radial.Error_pt"), factorize = FALSE, anova_table = list(es = "pes"))

knitr::kable(nice(ancova_assume_hp_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 144	267.64	0.14	<.001	.706
Instructions	1, 144	267.64	3.36 +	.023	.069
Radial.Error_pt	1, 144	267.64	3.26 +	.022	.073

Effect	df	MSE	F	pes	p.value
Expectation:Instructions	1, 144	267.64	0.62	.004	.431
Expectation:Radial.Error_pt	1, 144	267.64	0.05	<.001	.825
Instructions:Radial.Error_pt	1, 144	267.64	0.06	<.001	.809
Expectation:Instructions:Radial.Error_pt	1, 144	267.64	2.84 +	.019	.094

Testing homogeneity of regression slopes assumption for univariate (expectation) ANCOVA for high-pressure posttest for analogy instructions groups.

```
ancova_assume_analogy_hp_result <- aov_ez("ID", "Radial.Error", analogy_high, between=c("Expectation", "Radial.
Error_pt"), factorize = FALSE, anova_table = list(es = "pes"))

knitr::kable(nice(ancova_assume_analogy_hp_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 72	199.50	0.13	.002	.717
Radial.Error_pt	1, 72	199.50	3.63 +	.048	.061
Expectation:Radial.Error_pt	1, 72	199.50	1.85	.025	.178

Testing homogeneity of regression slopes assumption for univariate (expectation) ANCOVA for high-pressure posttest for explicit instructions groups.

```
ancova_assume_explicit_hp_result <- aov_ez("ID", "Radial.Error", explicit_high, between=c("Expectation", "Radia
l.Error_pt"), factorize = FALSE, anova_table = list(es = "pes"))

knitr::kable(nice(ancova_assume_explicit_hp_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 72	335.79	0.48	.007	.493
Radial.Error_pt	1, 72	335.79	0.80	.011	.376
Expectation:Radial.Error_pt	1, 72	335.79	1.18	.016	.280

2 (Expectation) x 2 (Instructions) x 3 (Block) mixed-factor ANCOVA with repeated-measures on the last factor, practice radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
practice_result = aov_ez(id = "ID", dv = "Radial.Error", between = c("Expectation", "Instructions"),within = "C
ondition", data = practice_long, covariate = "Radial.Error_pt", factorize = F, anova_table = list(es =  "pes"))

summary(practice_result)

##
## Univariate Type III Repeated-Measures ANOVA Assuming Sphericity
##
##                                     Sum Sq num Df Error SS den Df  F value
## (Intercept)                          72687      1    77848    146 136.3219
## Expectation                            906      1    77848    146   1.6988
## Instructions                            48      1    77848    146   0.0907
## Radial.Error_pt                      21104      1    77848    146  39.5794
## Expectation:Instructions               100      1    77848    146   0.1870
## Condition                             1269      2    78122    292   2.3713
## Expectation:Condition                  902      2    78122    292   1.6849
## Instructions:Condition                 162      2    78122    292   0.3021
## Radial.Error_pt:Condition             3938      2    78122    292   7.3599
## Expectation:Instructions:Condition    1241      2    78122    292   2.3186
##                                        Pr(>F)
## (Intercept)                         < 2.2e-16 ***
## Expectation                         0.1945008
## Instructions                        0.7637302
## Radial.Error_pt                     3.463e-09 ***
## Expectation:Instructions            0.6660941
## Condition                           0.0951568 .
## Expectation:Condition               0.1872669
## Instructions:Condition              0.7395043
## Radial.Error_pt:Condition           0.0007613 ***
## Expectation:Instructions:Condition  0.1002230
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Mauchly Tests for Sphericity
##
##                                     Test statistic    p-value
## Condition                                  0.87908 8.7535e-05
## Expectation:Condition                      0.87908 8.7535e-05
## Instructions:Condition                     0.87908 8.7535e-05
## Radial.Error_pt:Condition                  0.87908 8.7535e-05
## Expectation:Instructions:Condition         0.87908 8.7535e-05
##
```

```
##
## Greenhouse-Geisser and Huynh-Feldt Corrections
##  for Departure from Sphericity
##
##                                    GG eps Pr(>F[GG])
## Condition                         0.89213   0.101566
## Expectation:Condition             0.89213   0.190632
## Instructions:Condition            0.89213   0.714366
## Radial.Error_pt:Condition         0.89213   0.001243 **
## Expectation:Instructions:Condition 0.89213   0.106562
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                                      HF eps Pr(>F[HF])
## Condition                         0.9024166 0.10094156
## Expectation:Condition             0.9024166 0.19032693
## Instructions:Condition            0.9024166 0.71690991
## Radial.Error_pt:Condition         0.9024166 0.00118571
## Expectation:Instructions:Condition 0.9024166 0.10594657
```

```
knitr::kable(nice(practice_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 146	533.20	1.70	.012	.195
Instructions	1, 146	533.20	0.09	<.001	.764
Radial.Error_pt	1, 146	533.20	39.58 ***	.213	<.001
Expectation:Instructions	1, 146	533.20	0.19	.001	.666
Condition	1.78, 260.50	299.89	2.37	.016	.102
Expectation:Condition	1.78, 260.50	299.89	1.68	.011	.191
Instructions:Condition	1.78, 260.50	299.89	0.30	.002	.714
Radial.Error_pt:Condition	1.78, 260.50	299.89	7.36 **	.048	.001
Expectation:Instructions:Condition	1.78, 260.50	299.89	2.32	.016	.107

Anxiety analysis.

Creating separate anxiety datasets to calculate Cronbach's alpha and conduct the 2 (Expectation) x 2 (Instructions) x 2 (Posttest) ANOVA.

```
anxiety_raw_hp = subset(anxiety_raw_hp, ID != 72 & ID != 157 & ID != 30 & ID != 136)
anxiety_raw_lp = subset(anxiety_raw_lp, ID != 72 & ID != 157 & ID != 30 & ID != 136)
anxiety_subscales_long = subset(anxiety_subscales_long, ID != 72 & ID != 157 & ID != 30 & ID != 136)
```

Cronbach's alpha for cognitive subscale for the high-pressure posttest.

```
anxiety_raw_hp_cognitive = subset(anxiety_raw_hp, select = -c(1,2,3,4))
anxiety_raw_hp_cognitive = subset(anxiety_raw_hp_cognitive, select = c(2, 5, 8, 11, 14))
Cronbach::cronbach(anxiety_raw_hp_cognitive)

## [1] 0.8533163
```

Cronbach's alpha for cognitive subscale for the low-pressure posttest.

```
anxiety_raw_lp_cognitive = subset(anxiety_raw_lp, select = -c(1,2,3,4))
anxiety_raw_lp_cognitive = subset(anxiety_raw_lp_cognitive, select = c(2, 5, 8, 11, 14))
Cronbach::cronbach(anxiety_raw_lp_cognitive)

## [1] 0.8456958
```

Cronbach's alpha for somatic subscale for the high-pressure posttest.

```
anxiety_raw_hp_somatic = subset(anxiety_raw_hp, select = -c(1,2,3,4))
anxiety_raw_hp_somatic = subset(anxiety_raw_hp_somatic, select = c(1, 4, 6, 9, 12, 15, 17))
Cronbach::cronbach(anxiety_raw_hp_somatic)

## [1] 0.8930913
```

Cronbach's alpha for somatic subscale for the low-pressure posttest.

```
anxiety_raw_lp_somatic = subset(anxiety_raw_lp, select = -c(1,2,3,4))
anxiety_raw_lp_somatic = subset(anxiety_raw_lp_somatic, select = c(1, 4, 6, 9, 12, 15, 17))
Cronbach::cronbach(anxiety_raw_lp_somatic)

## [1] 0.88628
```

Computing correlation coefficients between subscales.

```
cor(anxiety_subscales_long$Somatic_lp, anxiety_subscales_long$Cognitive_lp, method = 'pearson')

## [1] 0.6311667

cor(anxiety_subscales_long$Somatic_hp, anxiety_subscales_long$Cognitive_hp, method = 'pearson')

## [1] 0.6435852
```

Self-reported anxiety by posttest and group.

```
anxiety_subscales_long_aov = subset(anxiety_subscales_long_aov, ID != 30 & ID != 72 & ID != 136 & ID != 157)

anxiety_descript = data.frame(aggregate(Average_anxiety ~ Group + Condition, anxiety_subscales_long_aov, functi
on(x) c(mean = MeanCI(x))))

print(anxiety_descript)
```

```
##   Group Condition Average_anxiety.mean.mean Average_anxiety.mean.lwr.ci
## 1   TCA        HP                  30.51855                     23.85165
## 2   TCE        HP                  29.00667                     24.67106
## 3   TTA        HP                  28.11947                     21.88559
## 4   TTE        HP                  28.22973                     22.19180
## 5   TCA        LP                  20.07382                     15.15731
## 6   TCE        LP                  19.30654                     14.50588
## 7   TTA        LP                  19.63829                     14.25713
## 8   TTE        LP                  17.46743                     13.28012
##   Average_anxiety.mean.upr.ci
## 1                    37.18545
## 2                    33.34227
## 3                    34.35336
## 4                    34.26766
## 5                    24.99032
## 6                    24.10719
## 7                    25.01945
## 8                    21.65474
```

2 (Expectation) x 2 (Instructions) x 2 (Posttest) mixed-factor ANOVA with repeated measures on the last factor and averaged self-reported anxiety serving as the dependent variable.

```
anova_anxiety = aov_ez(id = "ID", dv =  "Average_anxiety", data = anxiety_subscales_long_aov, between=c("Expect
ation", "Instructions"),within=c("Condition"), anova_table = list(es = "pes"))

knitr::kable(nice(anova_anxiety))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 148	481.94	0.29	.002	.589
Instructions	1, 148	481.94	0.19	.001	.667
Expectation:Instructions	1, 148	481.94	0.00	<.001	.983
Condition	1, 148	54.16	136.03 ***	.479	<.001
Expectation:Condition	1, 148	54.16	0.07	<.001	.790
Instructions:Condition	1, 148	54.16	0.21	.001	.650
Expectation:Instructions:Condition	1, 148	54.16	0.80	.005	.372

Free recall analysis.

Descriptives.

```
free_recall = subset(free_recall, ID != 157 & ID != 30 & ID != 72 & ID != 136)

allconcepts_descript = data.frame(aggregate(All_concepts ~ Group, free_recall, function(x) c(mean = MeanCI(x)))
)

hyptest_descript = data.frame(aggregate(Hypothesis_testing ~ Group, free_recall, function(x) c(mean = MeanCI(x)
)))

print(allconcepts_descript)
```

```
##   Group All_concepts.mean.mean All_concepts.mean.lwr.ci
## 1   TCA                2.052632                 1.575715
## 2   TCE                3.846154                 3.239526
## 3   TTA                1.763158                 1.321284
## 4   TTE                3.694444                 3.101084
##   All_concepts.mean.upr.ci
## 1                 2.529548
## 2                 4.452782
## 3                 2.205032
## 4                 4.287805
```

```
print(hyptest_descript)
```

```
##   Group Hypothesis_testing.mean.mean Hypothesis_testing.mean.lwr.ci
## 1   TCA                   0.52631579                     0.27591176
## 2   TCE                   0.58974359                     0.30443844
## 3   TTA                   0.63157895                     0.28624276
## 4   TTE                   0.22222222                     0.05822803
##   Hypothesis_testing.mean.upr.ci
## 1                     0.77671982
```

```
## 2                     0.87504874
## 3                     0.97691514
## 4                     0.38621641
```

Running multivariate normallity test.

```
df_free_recall = subset(free_recall, select = c("All_concepts", "Hypothesis_testing"))

mshapiro.test(t(df_free_recall))

##
##  Shapiro-Wilk normality test
##
## data:  Z
## W = 0.74748, p-value = 8.011e-15
```

Box test.

```
box_m(subset(free_recall, select = c("All_concepts","Hypothesis_testing")), free_recall$Group)

## # A tibble: 1 x 4
##   statistic  p.value parameter method
##       <dbl>    <dbl>     <dbl> <chr>
## 1      29.1 0.000620         9 Box's M-test for Homogeneity of Covariance Matri~
```

Since the normallity assumption failed, we are running two separate ANOVAs for all concepts and hyposthesis testing.

2 (Expectation) x 2 (Instructions) ANOVA with all concepts serving as dependent variable.

```
all.conc = aov_ez(id = "ID", dv = "All_concepts", between = c("Expectation", "Instructions"), data = free_recal
l, anova_table = list(es = "pes"))
knitr::kable(nice(all.conc))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	2.62	0.70	.005	.404
Instructions	1, 147	2.62	49.89 ***	.253	<.001
Expectation:Instructions	1, 147	2.62	0.07	<.001	.794

2 (Expectation) x 2 (Instructions) ANOVA with hypothesis testing serving as dependent variable.

```
hypot.test = aov_ez(id = "ID", dv = "Hypothesis_testing", between = c("Expectation", "Instructions"), data = fr
ee_recall, anova_table = list(es = "pes"))
knitr::kable(nice(hypot.test))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	0.68	0.95	.006	.330
Instructions	1, 147	0.68	1.66	.011	.200
Expectation:Instructions	1, 147	0.68	3.10 +	.021	.080

Cronbach alpha for the Movement Specific Reinvestment Scale.

```
reinvestment = subset(item_level_questionnaire_data, select = c(42,43,44,45,46,47,48,49,50,51))
reinvestment = na.omit(reinvestment)
Cronbach::cronbach(reinvestment)

## [1] 0.7781088
```

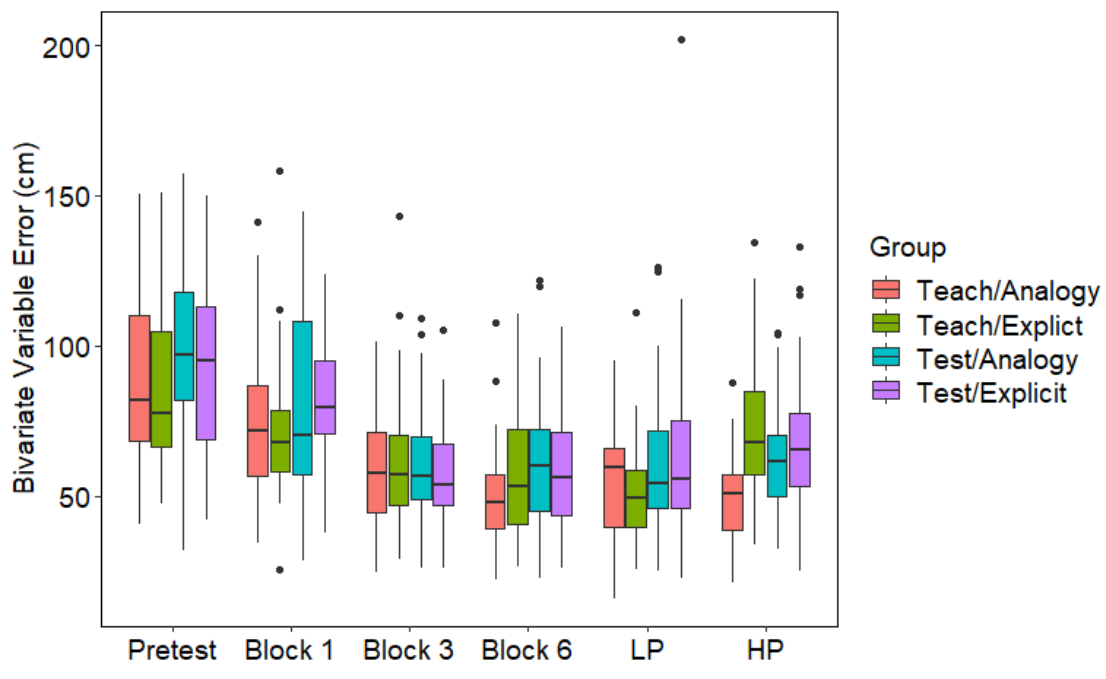
Supplementary Analyses

Statistical Analyses and Results Reported in the Supplemental Results

Putting precision.

Plotting bivariate variable error as a function of study phase and group.

```
data_plot_bve = subset(data_for_statistical_analyses, select = c(1,6,7,8,15,16,17,18,19,20))

data_plot_bve_long = melt(data_plot_bve, id.vars=c("ID", "Expectation", "Instructions", "Group"))
names(data_plot_bve_long)[names(data_plot_bve_long) == "variable"] <- "Condition"
names(data_plot_bve_long)[names(data_plot_bve_long) == "value"] <- "BVE"

data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_lp", "LP", data_plot_bve_long$Condition
)
data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_hp", "HP", data_plot_bve_long$Condition
)
data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_pt", "Pretest", data_plot_bve_long$Cond
ition)
data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_b1", "Block 1", data_plot_bve_long$Cond
ition)
data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_b3", "Block 3", data_plot_bve_long$Cond
ition)
data_plot_bve_long$Condition = data_plot_bve_long$Condition = gsub("BVE_b6", "Block 6", data_plot_bve_long$Cond
ition)

data_plot_bve_long$Group = data_plot_bve_long$Group = gsub("TTA", "Test/Analogy", data_plot_bve_long$Group)
data_plot_bve_long$Group = data_plot_bve_long$Group = gsub("TTE", "Test/Explicit", data_plot_bve_long$Group)
data_plot_bve_long$Group = data_plot_bve_long$Group = gsub("TCA", "Teach/Analogy", data_plot_bve_long$Group)
data_plot_bve_long$Group = data_plot_bve_long$Group = gsub("TCE", "Teach/Explict", data_plot_bve_long$Group)

data_plot_bve_long = subset(data_plot_bve_long, ID != 30 & ID != 72 & ID != 136 & ID != 157)

ggplot(data_plot_bve_long, aes(x = Condition, y = BVE, fill = Group)) +
  geom_boxplot() +theme(axis.text.x = element_text(angle = 90), legend.position = "right")+
  theme_classic()+ labs(x = ' ') + scale_x_discrete(limits = c('Pretest', "Block 1", "Block 3", "Block 6", 'LP'
, 'HP'))+
  labs(y = "Bivariate Variable Error (cm)") +
  theme(axis.text.x = element_text(size = 14, color = "black"),
        axis.title.y = element_text(size = 14, color = "black"),
        axis.text.y = element_text(size = 14, color = "black"))+
  theme(legend.text = element_text(size = 14)) + theme(legend.title = element_text(size = 14))+
  theme(panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=.5))
```



2 (Expectation) x 2 (Instructions) x 2 (Posttest) mixed-factor ANCOVA with repeated-measures on the last factor, posttest bivariate error serving as the dependent variable, and pretest bivariate variable error serving as the covariate.

```
posttest_long_supplement_bve = melt(posttest_wide_supplement, id.vars=c("ID", "Expectation", "Instructions", "G
roup", "Radial.Error_pt", "Radial.Error_lp", "Radial.Error_hp", "BVE_pt", "z_RE_low", "z_RE_high", "Did.not.fol
.rule"))
names(posttest_long_supplement_bve)[names(posttest_long_supplement_bve) == "variable"] <- "Condition"
```

```
names(posttest_long_supplement_bve)[names(posttest_long_supplement_bve) == "value"] <- "BVE"

posttest_long_supplement_bve$Condition = posttest_long_supplement_bve$Condition = gsub("BVE_lp", "LP", posttest
_long_supplement_bve$Condition)
posttest_long_supplement_bve$Condition = posttest_long_supplement_bve$Condition = gsub("BVE_hp", "HP", posttest
_long_supplement_bve$Condition)

posttest_long_supplement_bve = subset(posttest_long_supplement_bve, ID != 30 & ID != 72 & ID != 136 & ID != 157
)

bve_posttest_result = aov_ez(id = "ID", dv = "BVE", data = posttest_long_supplement_bve, between = c("Expectati
on", "Instructions"), within = "Condition", covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes")
)

knitr::kable(nice(bve_posttest_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	537.33	5.41 *	.036	.021
Instructions	1, 147	537.33	6.79 *	.044	.010
BVE_pt	1, 147	537.33	1.13	.008	.289
Expectation:Instructions	1, 147	537.33	0.63	.004	.428
Condition	1, 147	398.32	1.79	.012	.183
Expectation:Condition	1, 147	398.32	0.93	.006	.336
Instructions:Condition	1, 147	398.32	10.92 **	.069	.001
BVE_pt:Condition	1, 147	398.32	0.54	.004	.463
Expectation:Instructions:Condition	1, 147	398.32	4.24 *	.028	.041

Because the three-way interaction was statistically significant, we followed it up with separate ANCOVAs for low- and high-pressure posttests.

2 (Expectation) x 2 (Instructions) ANCOVA with low-pressure posttest bivariate variable error serving as the dependent variable, and pretest bivariate variable error serving as the covariate.

```
posttest_long_supplement_bve_lp = subset(posttest_long_supplement_bve, Condition == "LP")

bve_posttest_result_low = aov_ez(id = "ID", dv = "BVE", data = posttest_long_supplement_bve_lp, between = c("Ex
pectation", "Instructions"), covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(bve_posttest_result_low))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	520.14	5.15 *	.034	.025
Instructions	1, 147	520.14	0.03	<.001	.863
BVE_pt	1, 147	520.14	1.49	.010	.224
Expectation:Instructions	1, 147	520.14	0.50	.003	.483

2 (Expectation) x 2 (Instructions) ANCOVA with high-pressure posttest bivariate variable error serving as the dependent variable, and pretest bivariate variable error serving as the covariate.

```
posttest_long_supplement_bve_hp = subset(posttest_long_supplement_bve, Condition == "HP")

bve_posttest_result_high = aov_ez(id = "ID", dv = "BVE", data = posttest_long_supplement_bve_hp, between = c("E
xpectation", "Instructions"), covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes"))

## Warning: Numerical variables NOT centered on 0 (i.e., likely bogus results):
## BVE_pt

knitr::kable(nice(bve_posttest_result_high))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 147	415.51	1.45	.010	.231
Instructions	1, 147	415.51	19.21 ***	.116	<.001
BVE_pt	1, 147	415.51	0.12	<.001	.730
Expectation:Instructions	1, 147	415.51	4.26 *	.028	.041

Because the two-way interaction was statistically significant, we followed it up with separate univariate (expectation) ANCOVAs for analogy and explicit instructions groups.

Univariate ANCOVAs (expectation) for the analogy and explicit instructions groups with high-pressure posttest bivariate variable error serving as the dependent variable, and pretest bivariate variable error serving as the covariate.

```
posttest_long_supplement_bve_hp_analogy = subset(posttest_long_supplement_bve_hp, Instructions == "Analogy")

bve_posttest_result_high_analogy = aov_ez(id = "ID", dv = "BVE", data = posttest_long_supplement_bve_hp_analogy
```

```
, between = "Expectation", covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(bve_posttest_result_high_analogy))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 73	325.11	6.81 *	.085	.011
BVE_pt	1, 73	325.11	0.04	<.001	.841

```
posttest_long_supplement_bve_hp_explicit = subset(posttest_long_supplement_bve_hp, Instructions == "Explicit")

bve_posttest_result_high_explicit = aov_ez(id = "ID", dv = "BVE", data = posttest_long_supplement_bve_hp_explic
it, between = "Expectation", covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(bve_posttest_result_high_explicit))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 73	511.52	0.30	.004	.586
BVE_pt	1, 73	511.52	0.08	.001	.775

2 (Expectation) x 2 (Instructions) x 3 (Block) mixed-factor ANCOVA with repeated-measures on the last factor, practice bivariate variable error serving as the dependent variable, and pretest bivariate variable error serving as the covariate.

```
practice_bve = subset(data_for_statistical_analyses, select = c(1,6,7,8,15,16,17,18))

practice_bve = subset(practice_bve, ID != 30 & ID != 72 & ID !=136 & ID != 157)

practice_long_bve = melt(practice_bve, id.vars=c("ID", "Expectation", "Instructions", "Group", "BVE_pt"))

names(practice_long_bve)[names(practice_long_bve) == "variable"] <- "Condition"
names(practice_long_bve)[names(practice_long_bve) == "value"] <- "BVE"

practice_long_bve$Condition = practice_long_bve$Condition = gsub("BVE_b1", "Block 1", practice_long_bve$Conditi
on)
practice_long_bve$Condition = practice_long_bve$Condition = gsub("BVE_b3", "Block 3", practice_long_bve$Conditi
on)
practice_long_bve$Condition = practice_long_bve$Condition = gsub("BVE_b6", "Block 6", practice_long_bve$Conditi
on)

bve_practice_result = aov_ez(id = "ID", dv = "BVE", data = practice_long_bve, between = c("Expectation", "Instr
uctions"), within = "Condition", covariate = "BVE_pt", factorize = F, anova_table = list(es = "pes"))

summary(bve_practice_result)

##
## Univariate Type III Repeated-Measures ANOVA Assuming Sphericity
##
##                                   Sum Sq num Df Error SS den Df  F value
## (Intercept)                        83240      1    89512    146 135.7700
## Expectation                         1515      1    89512    146   2.4715
## Instructions                          15      1    89512    146   0.0240
## BVE_pt                             17169      1    89512    146  28.0042
## Expectation:Instructions             261      1    89512    146   0.4250
## Condition                           1207      2    97716    292   1.8030
## Expectation:Condition               1277      2    97716    292   1.9074
## Instructions:Condition              460      2    97716    292   0.6876
## BVE_pt:Condition                   1225      2    97716    292   1.8299
## Expectation:Instructions:Condition  1585      2    97716    292   2.3682
##                                     Pr(>F)
## (Intercept)                       < 2.2e-16 ***
## Expectation                         0.11809
## Instructions                        0.87719
## BVE_pt                            4.349e-07 ***
## Expectation:Instructions            0.51548
## Condition                           0.16663
## Expectation:Condition               0.15031
## Instructions:Condition              0.50357
## BVE_pt:Condition                    0.16227
## Expectation:Instructions:Condition  0.09545 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Mauchly Tests for Sphericity
##
##                                   Test statistic p-value
## Condition                                0.97056 0.11455
## Expectation:Condition                    0.97056 0.11455
## Instructions:Condition                   0.97056 0.11455
## BVE_pt:Condition                         0.97056 0.11455
```

```
## Expectation:Instructions:Condition        0.97056 0.11455
##
##
## Greenhouse-Geisser and Huynh-Feldt Corrections
##  for Departure from Sphericity
##
##                                    GG eps Pr(>F[GG])
## Condition                          0.9714    0.16779
## Expectation:Condition              0.9714    0.15163
## Instructions:Condition             0.9714    0.49957
## BVE_pt:Condition                   0.9714    0.16348
## Expectation:Instructions:Condition 0.9714    0.09711 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##                                       HF eps Pr(>F[HF])
## Condition                          0.9843007 0.16726728
## Expectation:Condition              0.9843007 0.15103801
## Instructions:Condition             0.9843007 0.50138766
## BVE_pt:Condition                   0.9843007 0.16293280
## Expectation:Instructions:Condition 0.9843007 0.09635919
```

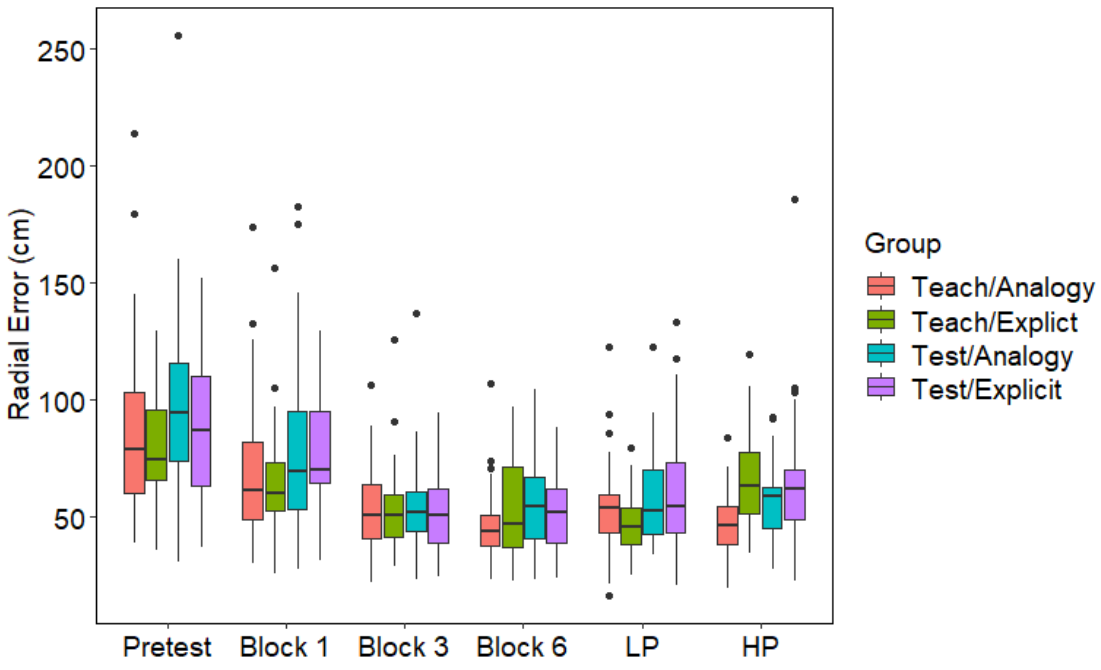
```
eta_squared(bve_practice_result, ci = 0.95)
```

```
## # Effect Size for ANOVA (Type III)
##
## Parameter                          | Eta2 (partial) |       95% CI
## -----------------------------------------------------------------
## Expectation                        |           0.02 | [0.00, 1.00]
## Instructions                       |       1.64e-04 | [0.00, 1.00]
## BVE_pt                             |           0.16 | [0.08, 1.00]
## Expectation:Instructions           |       2.90e-03 | [0.00, 1.00]
## Condition                          |           0.01 | [0.00, 1.00]
## Expectation:Condition              |           0.01 | [0.00, 1.00]
## Instructions:Condition             |       4.69e-03 | [0.00, 1.00]
## BVE_pt:Condition                   |           0.01 | [0.00, 1.00]
## Expectation:Instructions:Condition |           0.02 | [0.00, 1.00]
##
## - One-sided CIs: upper bound fixed at (1).
```

Putting accuracy with outliers included.

Plotting radial error as a function of study phase and group.

```
performance_all_woutliers$Condition = performance_all_woutliers$Condition = gsub("pt", "Pretest", performance_a
ll_woutliers$Condition)
performance_all_woutliers$Group = performance_all_woutliers$Group = gsub("TTA", "Test/Analogy", performance_all
_woutliers$Group)
performance_all_woutliers$Group = performance_all_woutliers$Group = gsub("TTE", "Test/Explicit", performance_al
l_woutliers$Group)
performance_all_woutliers$Group = performance_all_woutliers$Group = gsub("TCA", "Teach/Analogy", performance_al
l_woutliers$Group)
performance_all_woutliers$Group = performance_all_woutliers$Group = gsub("TCE", "Teach/Explict", performance_al
l_woutliers$Group)

ggplot(performance_all_woutliers, aes(x = Condition, y = Radial.Error, fill = Group)) +
  geom_boxplot() +theme(axis.text.x = element_text(angle = 90), legend.position = "right")+
  theme_classic()+ labs(x = ' ') + scale_x_discrete(limits = c('Pretest', "Block 1", "Block 3", "Block 6", 'LP'
, 'HP'))+
  labs(y = "Radial Error (cm)") +
  theme(axis.text.x = element_text(size = 14, color = "black"),
        axis.title.y = element_text(size = 14, color = "black"),
        axis.text.y = element_text(size = 14, color = "black"))+
  theme(legend.text = element_text(size = 14)) + theme(legend.title = element_text(size = 14))+
  theme(panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=.5))
```



2 (Expectation) x 2 (Instructions) x 2 (Posttest) mixed-factor ANCOVA with repeated-measures on the last factor, posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
posttest_w_outliers = aov_ez(id = "ID", dv = "Radial.Error", data = posttest_long_supplement, between = c("Expectation", "Instructions"), within = "Condition", covariate = "Radial.Error_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(posttest_w_outliers))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 151	500.93	5.24 *	.034	.024
Instructions	1, 151	500.93	6.54 *	.042	.012
Radial.Error_pt	1, 151	500.93	6.89 **	.044	.010
Expectation:Instructions	1, 151	500.93	0.00	<.001	.988
Condition	1, 151	254.38	1.62	.011	.205
Expectation:Condition	1, 151	254.38	1.22	.008	.270
Instructions:Condition	1, 151	254.38	18.16 ***	.107	<.001
Radial.Error_pt:Condition	1, 151	254.38	0.60	.004	.442
Expectation:Instructions:Condition	1, 151	254.38	8.31 **	.052	.005

Because the three-way interaction was statistically significant, we followed it up with separate ANCOVAs for low- and high-pressure posttests.

2 (Expectation) x 2 (Instructions) ANCOVA with low-pressure posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
posttest_long_supplement_low = subset(posttest_long_supplement, Condition == "LP")

posttes_w_outliers_low = aov_ez(id = "ID", dv = "Radial.Error", data = posttest_long_supplement_low, between = c("Expectation", "Instructions"), covariate = "Radial.Error_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(posttes_w_outliers_low))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 151	385.09	6.16 *	.039	.014
Instructions	1, 151	385.09	0.15	<.001	.700
Radial.Error_pt	1, 151	385.09	6.56 *	.042	.011
Expectation:Instructions	1, 151	385.09	2.78 +	.018	.097

2 (Expectation) x 2 (Instructions) ANCOVA with high-pressure posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
posttest_long_supplement_high = subset(posttest_long_supplement, Condition == "HP")

posttes_w_outliers_high = aov_ez(id = "ID", dv = "Radial.Error", data = posttest_long_supplement_high, between = c("Expectation", "Instructions"), covariate = "Radial.Error_pt", factorize = F, anova_table = list(es = "pes"))

knitr::kable(nice(posttes_w_outliers_high))
```

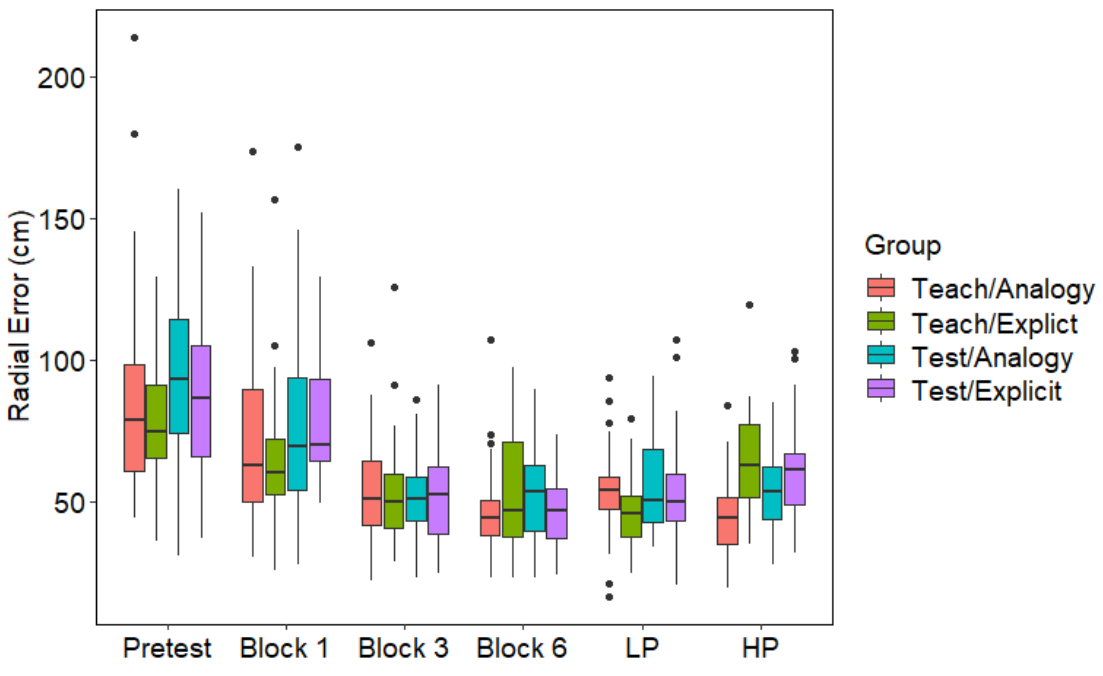
Effect	df	MSE	F	pes	p.value
Expectation	1, 151	370.22	1.52	.010	.219
Instructions	1, 151	370.22	21.17 ***	.123	<.001
Radial.Error_pt	1, 151	370.22	2.92 +	.019	.090

Effect	df	MSE	F	pes	p.value
Expectation:Instructions	1, 151	370.22	2.81 +	.018	.096

Putting accuracy excluding participants who did not follow instructions related to sleep, caffeine and/or alcohol.

Plotting radial error as a function of study phase and group.

```
performance_wide_excl_parti = subset(data_for_statistical_analyses, select = c(1,6,9,10,11,12,13,14,36))

performance_long_excl_parti = melt(performance_wide_excl_parti, id.vars=c("ID", "Group", "Did.not.fol.rule"))
names(performance_long_excl_parti)[names(performance_long_excl_parti) == "variable"] <- "Condition"
names(performance_long_excl_parti)[names(performance_long_excl_parti) == "value"] <- "Radial.Error"

performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_lp", "LP", p
erformance_long_excl_parti$Condition)
performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_hp", "HP", p
erformance_long_excl_parti$Condition)
performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_pt", "Pretes
t", performance_long_excl_parti$Condition)
performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_b1", "Block
1", performance_long_excl_parti$Condition)
performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_b3", "Block
3", performance_long_excl_parti$Condition)
performance_long_excl_parti$Condition = performance_long_excl_parti$Condition = gsub("Radial.Error_b6", "Block
6", performance_long_excl_parti$Condition)

performance_long_excl_parti$Group = performance_long_excl_parti$Group = gsub("TTA", "Test/Analogy", performance
_long_excl_parti$Group)
performance_long_excl_parti$Group = performance_long_excl_parti$Group = gsub("TTE", "Test/Explicit", performanc
e_long_excl_parti$Group)
performance_long_excl_parti$Group = performance_long_excl_parti$Group = gsub("TCA", "Teach/Analogy", performanc
e_long_excl_parti$Group)
performance_long_excl_parti$Group = performance_long_excl_parti$Group = gsub("TCE", "Teach/Explict", performanc
e_long_excl_parti$Group)

performance_long_excl_parti = subset(performance_long_excl_parti, Did.not.fol.rule == 0)

performance_long_excl_parti = subset(performance_long_excl_parti, ID != 30 & ID != 72 & ID != 136 & ID != 157)


ggplot(performance_long_excl_parti, aes(x = Condition, y = Radial.Error, fill = Group)) +
  geom_boxplot() +theme(axis.text.x = element_text(angle = 90), legend.position = "right")+
  theme_classic()+ labs(x = ' ') + scale_x_discrete(limits = c('Pretest', "Block 1", "Block 3", "Block 6", 'LP'
, 'HP'))+
  labs(y = "Radial Error (cm)") +
  theme(axis.text.x = element_text(size = 14, color = "black"),
        axis.title.y = element_text(size = 14, color = "black"),
        axis.text.y = element_text(size = 14, color = "black"))+
  theme(legend.text = element_text(size = 14)) + theme(legend.title = element_text(size = 14))+
  theme(panel.background = element_blank(),
        panel.grid.major = element_blank(),
        panel.grid.minor = element_blank(),
        axis.line = element_line(colour = "black"),
        panel.border = element_rect(colour = "black", fill=NA, size=.5))
```



2 (Expectation) x 2 (Instructions) x 2 (Posttest) mixed-factor ANCOVA with repeated-measures on the last factor, posttest radial error serving as the dependent variable, and pretest radial error serving as the covariate.

```
posttest_w_did_not_fol_rul = subset(posttest_long, Did.not.fol.rule == 0)

posttest_w_did_not_fol_rul_result = aov_ez(id = "ID", dv = "Radial.Error", data = posttest_w_did_not_fol_rul, b
etween = c("Expectation", "Instructions"), within = "Condition", covariate = "Radial.Error_pt", factorize = F,
anova_table = list(es = "pes"))

knitr::kable(nice(posttest_w_did_not_fol_rul_result))
```

Effect	df	MSE	F	pes	p.value
Expectation	1, 128	308.94	2.88 +	.022	.092
Instructions	1, 128	308.94	5.41 *	.041	.022
Radial.Error_pt	1, 128	308.94	2.87 +	.022	.092
Expectation:Instructions	1, 128	308.94	0.72	.006	.398
Condition	1, 128	214.77	0.67	.005	.416
Expectation:Condition	1, 128	214.77	0.68	.005	.410
Instructions:Condition	1, 128	214.77	21.24 ***	.142	<.001
Radial.Error_pt:Condition	1, 128	214.77	0.05	<.001	.825
Expectation:Instructions:Condition	1, 128	214.77	5.07 *	.038	.026