HUDM 5123: Final Project

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Abstract

The purpose of this paper was to examine the impact of guiding people to interpret their experienced difficulty as importance or impossibility on their academic performance with regard to different gender groups. A two-way ANOVA was calculated for 175 participants after meeting the assumptions. No statistically significant interaction was found for gender and the intervention on the academic performance. After two sets of comparisons using the Shaffer’s planned post-omnibus and the Holm-Bonferroni correction for type I error rate control, the group which received the difficulty-as-importance mindset intervention had a significantly better academic performance than the control group. No significant effect of the difficulty-as-impossibility mindset intervention was found.

**Introduction**

Previous motivation research shows that people have two major different interpretation-of-experienced-difficulty mindsets, the difficulty-as-impossibility mindset and the difficulty-as-importance mindset. The former one takes difficulty as an indicator of low odds of success while the latter views difficulty implying the high value of the task. It is widely believed that the former mindset hinders one’s performance while the latter improves that, which is especially so when the person is working on a relatively challenging task. Moreover, people’s mindsets are prone to change under suggestive hints. Therefore, this study aimed at testing the effect of different mindset interventions on student’s performance on difficult academic tasks.

**Methods**

**Participants**

The study worked on a dataset derived from an empirical study using randomized controlled trials (Oyserman et al., 2018). Participants were sixth graders in eight language arts classes (N = 175) from a Detroit-area middle school serving low-income families (66% of student body receives free/reduced price lunch). Eight observations with missing data were removed from the analysis.

**Instruments**

The data were collected in classroom settings where two mindset interventions were randomly assigned to students as two different kinds of booklets which had same covers but with four different statements on the difficulty-as-importance mindset or the difficulty-as-impossibility mindset inside. Apart from these two groups, there was also a control group which also received similar booklets but without any mindset primes (*n* = 163, difficulty-as-importance *n* = 51, difficulty-as-impossibility *n* = 59, control *n* = 53.)

The outcome measure of this study is students’ score on a standardized writing test included in the booklet which was adapted from the Michigan Educational Assessment Program (MEAP). The score ranged from one (= low/ not proficient) to four (=advanced).

Since gender difference in writing is salient in childhood, participants’ gender is also included in the regression model.

**Procedure**

Descriptive statistics were calculated including sample size and the distribution of writing scores within each condition by gender group. Two-way ANOVA was used to examine the statistical significance of the interaction of mindset interventions and gender on the writing scores. Two assumptions of ANOVA, i.e. normality and homoscedasticity, were validated through calculating the z-score of standard error of skewness and applying the Levene’s test across groups. Two sets of follow-up comparisons were conducted to pinpoint which groups led to the overall difference in the writing score. When examining the pairwise comparisons among three conditions, the Shaffer’s planned post-omnibus was conducted to control the type I error rate where the p-value was compared to .05, i.e. the alpha level, .05, divided by the number of possible Type I errors, namely, one. When comparing two linear contrasts of the three conditions, the Holm-Bonferroni correction for type I error rate control was conducted where the p-value was compared to .025 and .05, i.e. the alpha level, .05, divided by the number of comparisons, two, for the first comparison and the alpha level divided by the number of comparisons minus one for the second comparison.

**Results**

Descriptive statistics can be found in Table 1 for the three conditions by two gender groups.

Table 1

*Descriptive Statistics of Participants in Each Group of Gender by Conditions*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Gender | Conditions | *n* | *%* | *M* | *SD* | *z-score of Skewness* |
| Male | Importance | 24 | 14.7 | 2.17 | 0.145 | 0.383 |
|  | Impossibility | 26 | 16.0 | 1.87 | 0.139 | 0.934 |
|  | Control | 23 | 14.1 | 2.05 | 0.148 | 2.244 |
| Female | Importance | 27 | 16.6 | 2.82 | 0.137 | 0.306 |
|  | Impossibility | 33 | 20.2 | 2.76 | 0.124 | 0.710 |
|  | Control | 30 | 18.4 | 2.69 | 0.130 | 0.253 |

The proportion of individuals within each group of gender by conditions was around one sixth, which indicated the even distribution of participants of different genders in three conditions and the independence of experimental conditions and gender.

Furthermore, with respect to the mean value of the writing scores for the six groups, they were around two, which was close to the medium score that can be earned out of the full score, four, showing no evident risk of floor or ceiling effects. Also, the six standard deviations of the writing scores were all about 0.1, around one twentieth of the scores, which implies quite centralized distributions of the writing scores within each group.

Before examining difference of mean writing scores across the six groups using the two-way ANOVA, two statistical requirements for this analysis were tested, i.e. normality and homoscedasticity. The six z-scores of the skewness statistics were all within the range from -3.09 to 3.09 meaning that the assumption of the data following the normal distribution was sound. In addition, the insignificance of the Levene’s test (*p* = .070) meant that the assumption of the equal variance across groups was also met. Since both requirements were satisfied, the ANOVA could be conducted on this dataset.

The two-way ANOVA results in Table 2 showed significant main effects of gender (*p* = .0005) and mindset interventions (*p* = .04) but no significant interaction effect (*p* = .15).

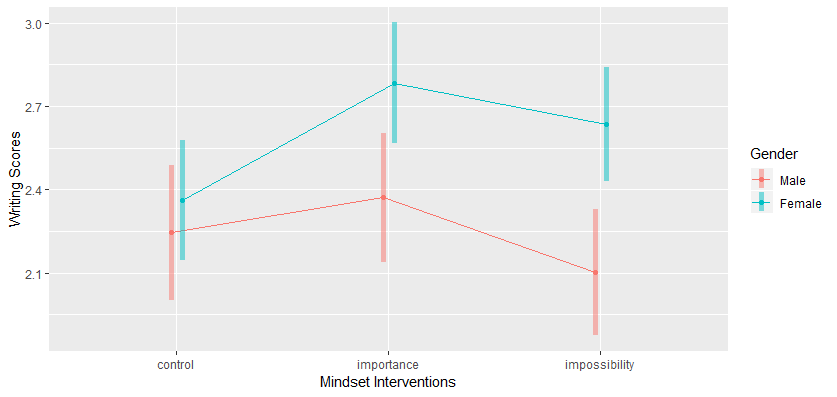
Table 2

*Two-Way Analysis of Variance in Writing Scores*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source | Sum of Squares | *df* | Mean Square | *F* Ratio | *p* |
| Mindsets | 2.08 | 2 | 1.04 | 3.25 | .0413\* |
| Gender | 4.05 | 1 | 4.05 | 12.68 | .0005\*\* |
| Mindsets × Gender | 1.23 | 2 | 0.62 | 1.92 | .1498 |
| Error | 48.9 | 153 | 0.32 |  |  |

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

The interaction plot with specified confidence intervals was demonstrated in Figure 1 to further illustrate the effects of mindset interventions and gender on student’s writing scores.



*Figure 1*. Interaction between gender and mindset interventions on students’ writing scores

Since the interaction was not significant and the main effect of mindset interventions was found, pairwise comparisons were conducted to locate the significant between-group differences.

Table 3 shows that the average writing score of those who received the difficulty-as-importance mindset intervention was significantly higher than the control group, *t*(153) = -2.425, *p* = .0165 < .05. No other significant effects were found among the pairs.

Table 3

*Pairwise Differences of the Main Effect of Three Mindset Interventions on Writing Scores*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Contrasts | *M* | *SE* | *t(*153*)* | *p* |
| Mindset Interventions |  |  |  |  |
| Control – Importance | -0.27 | 0.113 | -2.425 | .0165\* |
| Control – Impossibility | -0.06 | 0.112 | -0.569 | .5704 |
| Importance – Impossibility | 0.21 | 0.111 | 1.886 | .0612 |

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

Moreover, the contrast, -1 \* difficulty-as-importance + ½ \* difficulty-as-impossibility + ½ \* control, was tested significant, *t*(153) = -2.496, *p* = .0136 < .025, while the other contrast, ½ \* difficulty-as-importance – 1 \* difficulty-as-impossibility + ½ \* control, was not significant, , *t*(153) = 0.754, *p* = .4520 > .05, which evinced that being in the difficulty-as-importance condition significantly improved participants’ academic performance measured by writing scores compared to control and difficulty-as-impossibility conditions combined while being in the difficulty-as-impossibility condition neither improved or impaired participants’ performance significantly.

**Discussion**

This study showed that middle school students in a low social class context scored better on a standardized writing task when proffered an interpretation of experienced difficulty as importance than when proffered no interpretation of experienced difficulty at all (control group). Writing scores were not significantly different in the control group or the difficulty-as-impossibility group. We may inferred that when giving no cues at all (control group), students in this low social class context may have the mindset similar to the difficulty-as-impossibility group. Therefore, positive reinforcement of the difficulty-as-importance mindset can be an indispensable intervention for students in the low social class to improve their academic performance.

The finding of this study replicate and expand on prior research around growth mindset and grit theories. Having a difficulty-as-importance mindset is conducive to performance even if such an mindset is elicited by a subtle prime. The fact that the prime is subtle also points to accessibility as a possible mechanism through which the mindset effect occurs – because students did not actively question why a particular interpretation came to mind, they instead used the most easily accessible interpretation to respond to difficulty.

Any set of studies has limitations and this study is no exception. The first limitation is related to the subtle prime mentioned above. Since this study only measured immediate effects of the subtle manipulation, the duration of the effects of mindset interventions cannot be concluded right now. Secondly, the measure of academic performance using a standardized writing test limited the domain-general interpretation of the effect of the mindset intervention. Whether the positive impact of the difficulty-as-importance mindset can be transferred from literature to math or science needs to be further investigated. Thirdly, the current design excluded the possibility that difficulty-as-impossibility could be beneficial on some occasions, e.g. avoiding overinvestment and adjusting unattainable goals. Different kinds of tasks should be used to test effects of mindset interventions on participants’ non-academic performance.

Overall, the results suggest that efforts to remind students that difficulty can signal the important value of their work may keep more students on the path to academic success. Different contexts can be set up in the future to test the generalizability of the current finding.

References

Tabachnick, B. G. & Fidell, L. S. (2007). *Using multivariate statistics* (5th Ed.). Boston, MA: Pearson, Allyn & Bacon.

**Appendix**

*R codes for the analyses in this paper*

# Upload the dataset

ms2 <- read.csv("HUDM5123\_FinalProject\_02\_zz2404.csv", header = TRUE)

# Rename the first column

names(ms2)[1] <- c("conditions")

# Change the variable of gender to the factor type

ms2$gender\_fac <- factor(x=ms2$gender,

levels = 0:1,

labels = c("Male", "Female"))

# Descriptive Statistics

lm0 <- lm(formula=scores~gender\_fac\*conditions, data=ms2)

library(emmeans)

emmeans(object=lm0, spec=~conditions\*gender\_fac)

# Assumption Check: Normality

spssSkewKurtosis=function(x) {

w=length(x)

m1=mean(x)

m2=sum((x-m1)^2)

m3=sum((x-m1)^3)

m4=sum((x-m1)^4)

s1=sd(x)

skew=w\*m3/(w-1)/(w-2)/s1^3

sdskew=sqrt( 6\*w\*(w-1) / ((w-2)\*(w+1)\*(w+3)) )

kurtosis=(w\*(w+1)\*m4 - 3\*m2^2\*(w-1)) / ((w-1)\*(w-2)\*(w-3)\*s1^4)

sdkurtosis=sqrt( 4\*(w^2-1) \* sdskew^2 / ((w-3)\*(w+5)) )

mat=matrix(c(skew,kurtosis, sdskew,sdkurtosis), 2,

dimnames=list(c("skew","kurtosis"), c("estimate","se")))

return(mat)

}

spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 2.244032 < 3.09, Pass Normality Check

spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Female"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 0.2530942 < 3.09, Pass Normality Check

spssSkewKurtosis(ms2[which(ms2$conditions=="importance" & ms2$gender\_fac=="Male"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 0.3832331 < 3.09, Pass Normality Check

spssSkewKurtosis(ms2[which(ms2$conditions=="importance" & ms2$gender\_fac=="Female"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 0.3056062 < 3.09, Pass Normality Check

spssSkewKurtosis(ms2[which(ms2$conditions=="impossibility" & ms2$gender\_fac=="Male"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 0.933647 < 3.09, Pass Normality Check

spssSkewKurtosis(ms2[which(ms2$conditions=="impossibility" & ms2$gender\_fac=="Female"),"scores"])[1,1]/spssSkewKurtosis(ms2[which(ms2$conditions=="control" & ms2$gender\_fac=="Male"),"scores"])[1,2]

## -3.09 < 0.7098966 < 3.09, Pass Normality Check

# Assumption Check: Homoscedasticity

ms2$groups <- paste(ms2$conditions,ms2$gender\_fac)

library(lawstat)

levene.test(ms2[,"scores"], ms2[,c("groups")])

## p-value = .06991 > .05, No evidence for heteroscedasticity, Pass Homoscedasticity Check.

## The data meet both the assumptions for a ANOVA test, the ANOVA test can be carried out from here on.

# Change the default handling of unordered factors to deviation coding (contr.sum)

options(contrasts=c("contr.sum", "contr.poly"))

# Fit the linear regression model to conduct ANCOVA, DV = scores, IVs = gender\*condition, COVs = effort, grade, words, and sentences

lm1 <- lm(formula = scores ~ conditions\*gender\_fac + z\_effort + z\_grade + z\_words + z\_sentences, data = ms2)

# The ANOVA Source Table

library(car)

Anova(lm1, type=3) # interaction is not significant, p-value = .15

# The Interaction Plot

library(emmeans)

emm1<-emmeans(object = lm1, spec=~conditions\*gender\_fac)

ip1 <- emmip(object=emm1, formula = gender\_fac ~ conditions, xlab=c("Mindset Interventions"), ylab=c("Writing Scores"), CIs = TRUE, ylim=c(0,4))

ip1$labels$colour <- "Gender"

print(ip1)

# Pairwise comparisons

emm1.m<-emmeans(object = lm1, spec=~conditions) # the main effect of conditions

pairs(emm1.m, adjust="none")

## The only significant pair is "control - importance". p-value = .0165 < .05/1, the Shaffer's Planned Post-Omnibus

# Linear contrasts

contrast(emm1.m, method=list(c(1/2,-1,1/2))) # importance vs others

## Significant, p-value = .0136 < .05/2, the Holm-Bonferroni Correction

contrast(emm1.m, method=list(c(1/2,1/2,-1))) # impossibility vs others

## Not significant, p-value = .4520