Network Demasking

Reading the Data

```
library(dplyr)
netdemask = read.csv("Compiled_NetworksE3_final.csv", header = TRUE, sep = ",")
## filtering out incorrect target responses
netdemask = netdemask %>% filter(TargetAccuracy == 1)
```

PL Dist

```
netdemask2 = read.csv("Compiled_NetworksE3_final.csv", header = TRUE, sep = ",")

item_dist = group_by(netdemask2, Procedure, Stimuli1) %>%
  summarise_at(vars(pathlength, Undirected, Directed), mean)
## count distribution of items
library(dplyr)
undirected_items = group_by(item_dist, Procedure, pathlength, Undirected) %>%
  summarize(undirecteditems = n())
undirected_items$undirectedpercent = undirected_items$undirecteditems/40

undirected_rmisc = Rmisc::summarySE(undirected_items,
                                    measurevar = "undirectedpercent",
                                    groupvars = c("pathlength", "Undirected"))

directed_items = group_by(item_dist, Procedure, pathlength, Directed) %>%
  summarize(directeditems = n())
directed_items$directedpercent = directed_items$directeditems/40

directed_rmisc = Rmisc::summarySE(directed_items,
                                    measurevar = "directedpercent",
                                    groupvars = c("pathlength", "Directed"))
```

```
## Warning in qt(conf.interval/2 + 0.5, datac$N - 1): NaNs produced
```

Raw Reaction Time

```
netdemask_rt = group_by(netdemask, subject, pathlength ) %>%
  summarise_at(vars(RTRecogniseTarget), mean)

netdemask_rt_agg = Rmisc::summarySE(netdemask_rt,
                          measurevar = "RTRecogniseTarget",
                          groupvars = c("pathlength"))
```

ANOVA

```
netdemask_rt$pathlengthfac = ordered(as.factor(as.character(netdemask_rt$pathlength)),
                            levels = c("1", "2", "3", "4", "6", "15"))
netdemask_rt$subject = as.factor(netdemask_rt$subject)
rt_aov = aov(data = netdemask_rt, RTRecogniseTarget ~ pathlengthfac +
                      Error(subject/(pathlengthfac)))
summary(rt_aov)
```

```
##
## Error: subject
##           Df    Sum Sq Mean Sq F value Pr(>F)
## Residuals 38 125235990 3295684
##
## Error: subject:pathlengthfac
##                 Df  Sum Sq Mean Sq F value Pr(>F)
## pathlengthfac    5 3378610  675722   36.41 <2e-16 ***
## Residuals      190 3525637   18556
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Plotting RTs

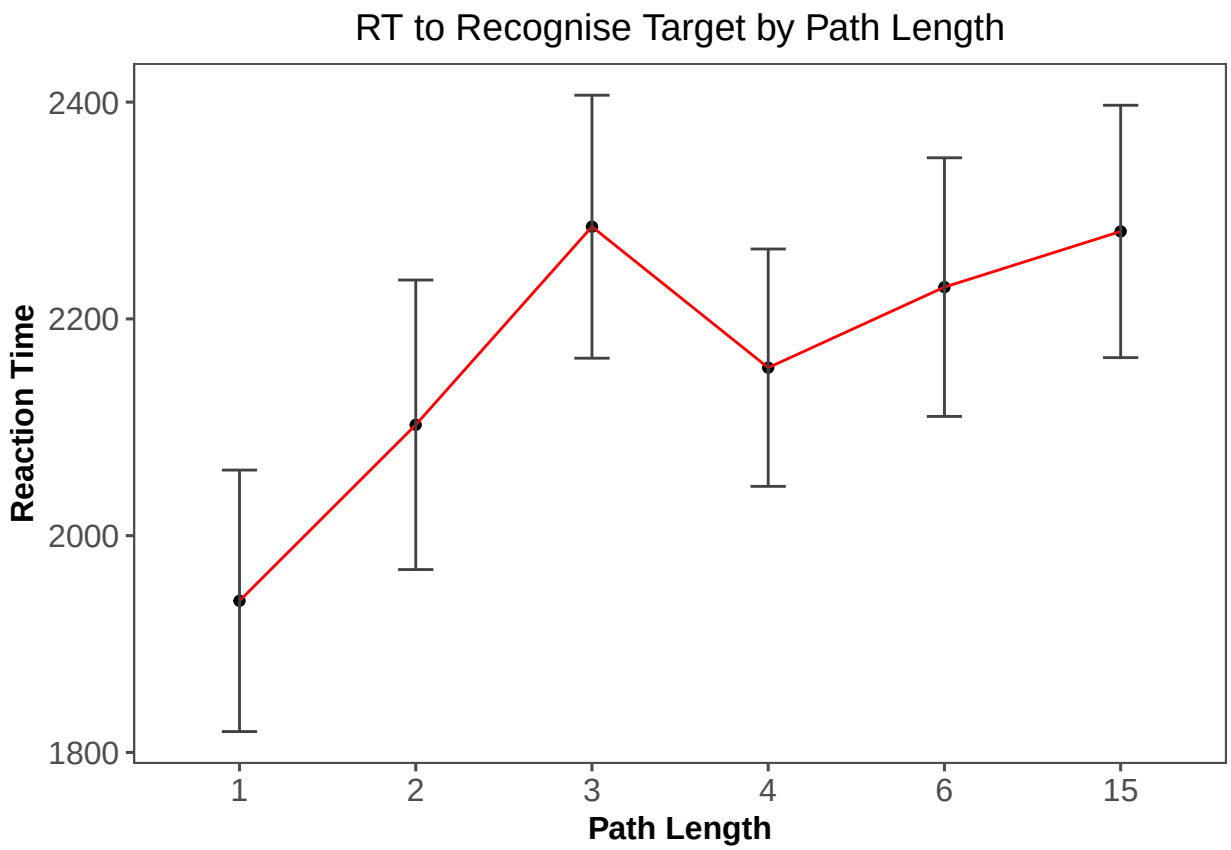
```
netdemask_rt_agg$pathlengthfac = ordered(as.factor(as.character(netdemask_rt_agg$pathlength)),

library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 3.4.4
```

```
library(ggthemes)
```

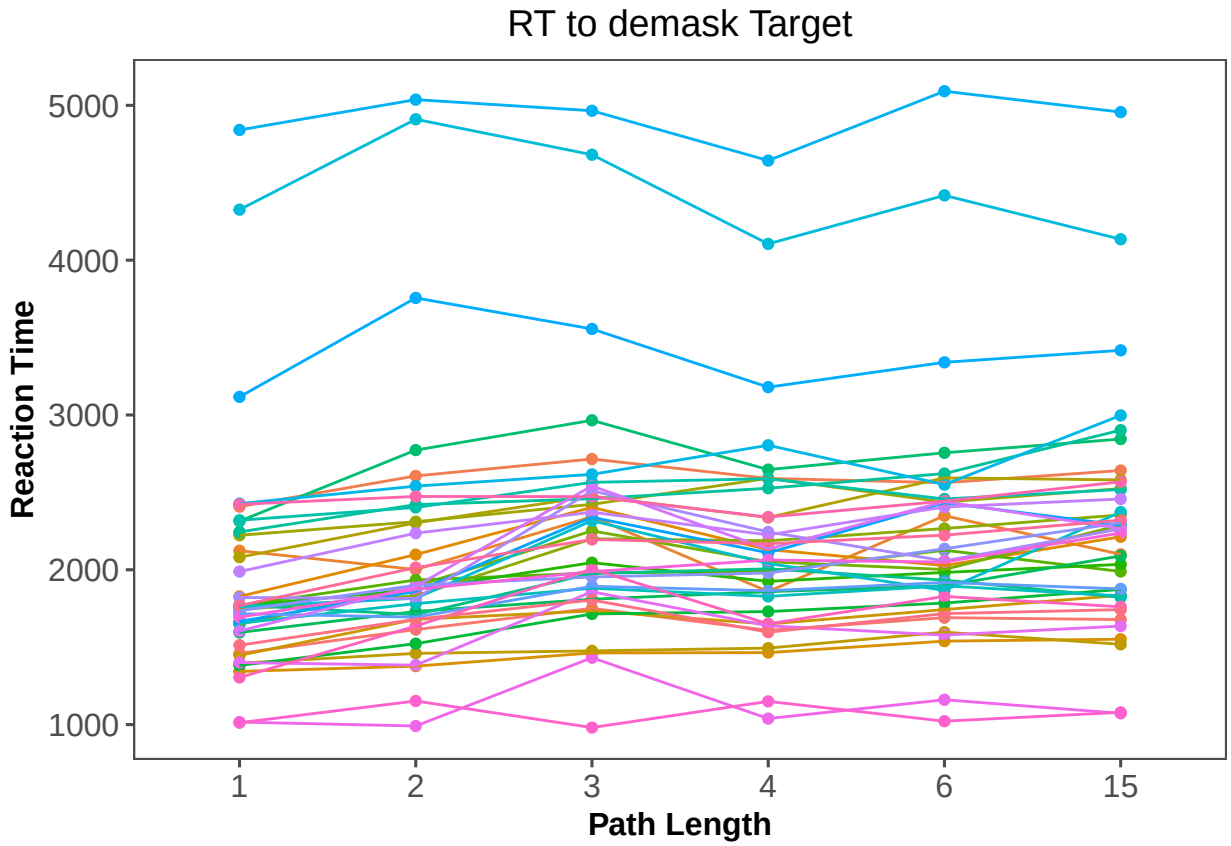
```
## Warning: package 'ggthemes' was built under R version 3.4.4
```

```
netdemask_rt_agg %>%
  ggplot(aes(x = pathlengthfac, y = RTRecogniseTarget, group = 1))+
  geom_point()+
  geom_line(color = "red")+
   geom_errorbar(aes(ymin=RTRecogniseTarget - se, ymax=RTRecogniseTarget + se),
             width=.2, color = "gray26",
             position = position_dodge(0.7))+
 theme_few()+
 # scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("Reaction Time") +
  ggtitle("RT to Recognise Target by Path Length")  +
   theme(axis.text = element_text(size = rel(1)),
          axis.title = element_text(face = "bold", size = rel(1)),
          legend.title = element_text(face = "bold", size = rel(1)),
         plot.title = element_text(hjust = .5),
         strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



Subject-Wise

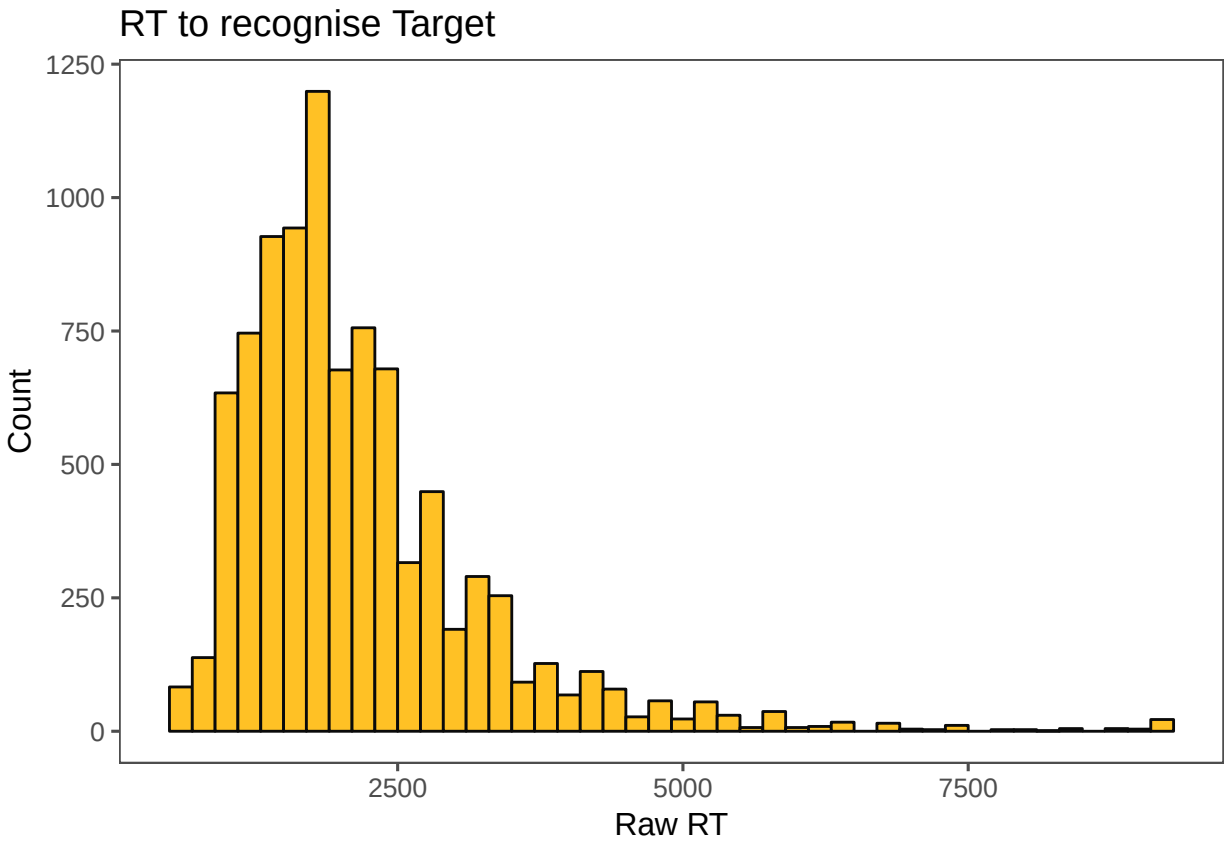
```
library(ggplot2)
library(ggthemes)

netdemask_rt %>%
  ggplot(aes(x = pathlengthfac, y = RTRecogniseTarget,
             group = subject, color = subject))+
  geom_point()+
  geom_line()+
 theme_few()+
  guides(color = FALSE)+
 # scale_x_continuous(breaks = c(1,2,3,4,6,15))+
    xlab("Path Length") + ylab("Reaction Time") +
  ggtitle("RT to demask Target")  +
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
         legend.title = element_blank(),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



z-scored Reaction Time

Histogram of RT

```
library(ggplot2)
library(ggthemes)
ggplot(netdemask, aes(x = RTRecogniseTarget))+
geom_histogram(binwidth = 200, color = "gray4", fill = "goldenrod1")+
    theme_few()+
  #facet_wrap(~subject)+
  xlab("Raw RT") + ylab("Count") +
  ggtitle("RT to recognise Target")
```



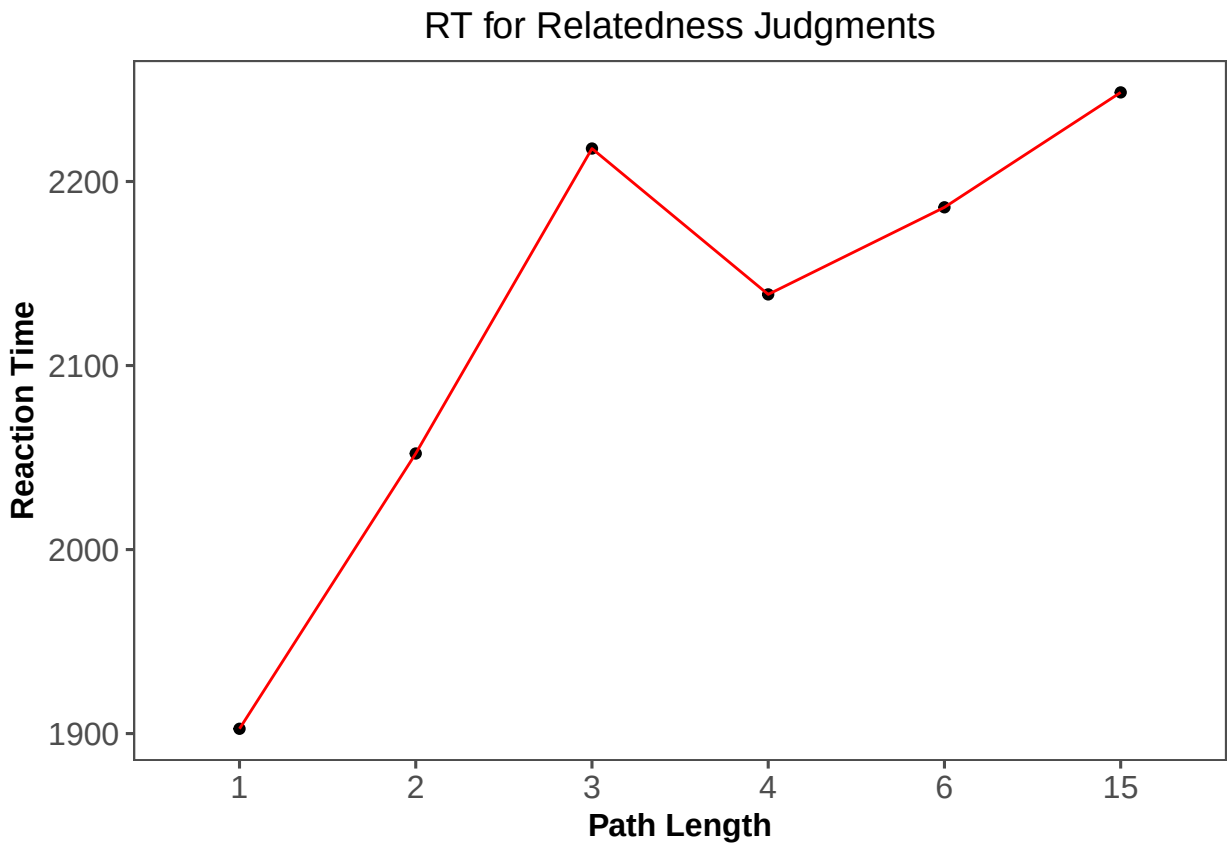
First Trim

```
library(dplyr)
netdemask_firsttrim = netdemask %>% filter(RTRecogniseTarget > 250 &
                                           RTRecogniseTarget < 7000)
```

Raw RT aggregates After Trimming

```
netdemask_rt_firsttrim = group_by(netdemask_firsttrim, subject, pathlength ) %>%
  summarise_at(vars(RTRecogniseTarget), mean)

netdemask_rt_agg_firsttrim = group_by(netdemask_firsttrim, pathlength ) %>%
  summarise_at(vars(RTRecogniseTarget), mean)

netdemask_rt_agg_firsttrim$pathlengthfac = ordered(as.factor(as.character(netdemask_rt_agg_firsttrim$pa

library(ggplot2)
library(ggthemes)

netdemask_rt_agg_firsttrim %>%
  ggplot(aes(x = pathlengthfac, y = RTRecogniseTarget, group = 1))+
  geom_point()+
  geom_line(color = "red")+
```

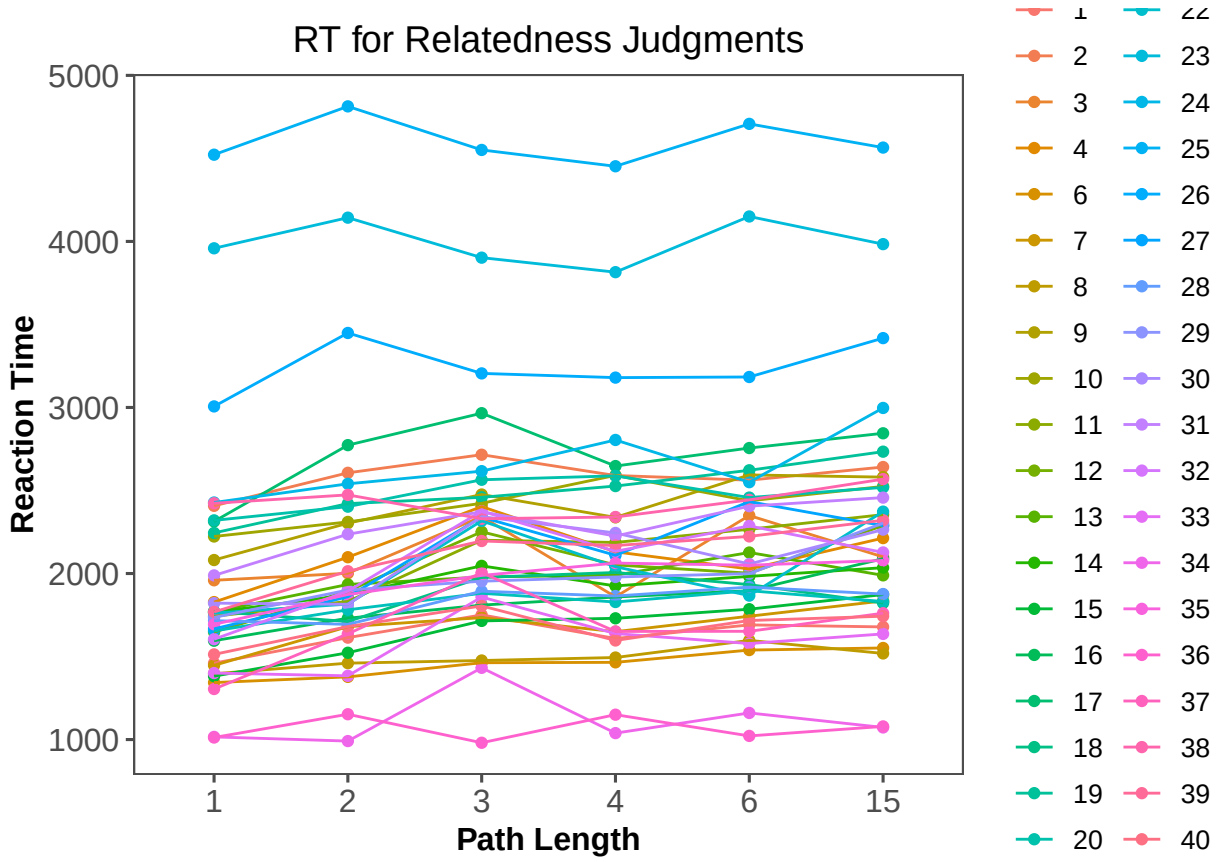
```
  #geom_errorbar(aes(ymin=Trials - ci, ymax=Trials + ci),
 #           width=.2, color = "gray26",
  #          position = position_dodge(0.7))+
theme_few()+
 #scale_x_continuous(breaks = c(1,2,3,4,6,15))+
   xlab("Path Length") + ylab("Reaction Time") +
 ggtitle("RT for Relatedness Judgments")  +
  theme(axis.text = element_text(size = rel(1)),
        axis.title = element_text(face = "bold", size = rel(1)),
        legend.title = element_text(face = "bold", size = rel(1)),
       plot.title = element_text(hjust = .5),
       strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



Subject Raw RT again

```
library(ggplot2)
library(ggthemes)

netdemask_rt_firsttrim$pathlengthfac = ordered(as.factor(as.character(netdemask_rt_firsttrim$pathlength
                            levels = c("1", "2", "3", "4", "6", "15"))
netdemask_rt_firsttrim$subject = as.factor(netdemask_rt_firsttrim$subject)
netdemask_rt_firsttrim %>%
  ggplot(aes(x = pathlengthfac, y = RTRecogniseTarget,
             group = subject, color = subject))+
  geom_point()+
```

```
  geom_line()+
   #geom_errorbar(aes(ymin=Trials - ci, ymax=Trials + ci),
  #           width=.2, color = "gray26",
   #          position = position_dodge(0.7))+
 theme_few()+
  #guides(color = FALSE)+
#  scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("Reaction Time") +
  ggtitle("RT for Relatedness Judgments")  +
 # facet_wrap(~subject)+
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



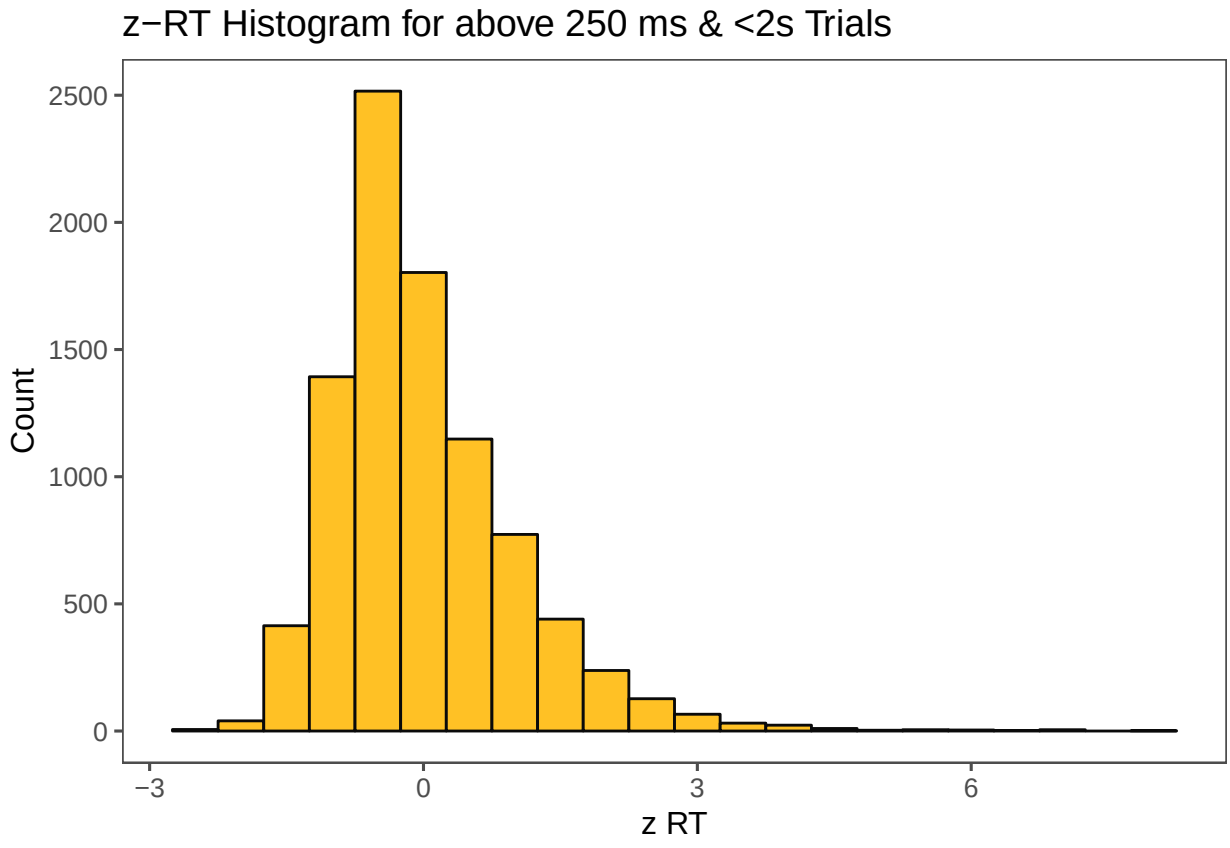
Making the z-scores

```
## aggregate per subject all IVs and DVs
meanRT = group_by(netdemask_firsttrim, subject) %>%
  summarise_at(vars(RTRecogniseTarget), mean)
colnames(meanRT) = c("subject", "MeanRTTarget")

sdRT = group_by(netdemask_firsttrim, subject) %>%
```

```
  summarise_at(vars(RTRecogniseTarget), sd)
colnames(sdRT) = c("subject", "sdRTTarget")

RT_agg = merge(meanRT, sdRT, by = "subject")

## merge aggregate info with long data
netdemask_z = merge(netdemask_firsttrim, RT_agg, by = "subject", all.x = T)

## person and grand-mean centered scores using original and aggregate
library(dplyr)
netdemask_z = netdemask_z %>% mutate(zRTTarget =
                            (RTRecogniseTarget - MeanRTTarget)/sdRTTarget)

## checking: subject level means should be zero

sub_pic = group_by(netdemask_z, subject) %>%
  summarise_at(vars(zRTTarget), mean)
```

z-RT Distribution

```
ggplot(netdemask_z, aes(x = zRTTarget))+
geom_histogram(binwidth = 0.5, color = "gray4", fill = "goldenrod1")+
    theme_few()+
  xlab("z RT") + ylab("Count") +
  ggtitle("z-RT Histogram for above 250 ms & <2s Trials")
```



Trimming z-RT

```
## trimming separately for prime and target
netdemask_z_trimmed_target = subset(netdemask_z, netdemask_z$zRTTarget < 3 &
                                netdemask_z$zRTTarget > -3)
nrow(netdemask_z_trimmed_target)
```

```
## [1] 8932
```

```
nrow(netdemask)
```

```
## [1] 9105
```

Repeating z-scoring

```
library(dplyr)
## FOR TARGET
## aggregate per subject all IVs and DVs
meanRT_trim_target = group_by(netdemask_z_trimmed_target, subject) %>%
  summarise_at(vars(RTRecogniseTarget), mean)
colnames(meanRT_trim_target) = c("subject", "MeanRT_trim_target")

sdRT_trim_target = group_by(netdemask_z_trimmed_target, subject) %>%
  summarise_at(vars(RTRecogniseTarget), sd)
colnames(sdRT_trim_target) = c("subject", "sdRT_trim_target")

RT_agg_trim_target = merge(meanRT_trim_target, sdRT_trim_target, by = "subject")

## merge aggregate info with long data
new_netdemask_z_target = merge(netdemask_z_trimmed_target,
                        RT_agg_trim_target, by = "subject", all.x = T)

## person and grand-mean centered scores using original and aggregate
library(dplyr)
new_netdemask_z_target = new_netdemask_z_target %>%
  mutate(zRTTarget_trim = (RTRecogniseTarget - MeanRT_trim_target)/sdRT_trim_target)

## checking: subject level means should be zero

sub_pic = group_by(new_netdemask_z_target, subject) %>%
  summarise_at(vars(zRTTarget_trim), mean)


new_netdemask_z = new_netdemask_z_target
(nrow(netdemask) -nrow(new_netdemask_z))/nrow(netdemask)
```

```
## [1] 0.01900055
```

Aggregating zRT

```
z_netdemask_rt = group_by(new_netdemask_z, subject, pathlength ) %>%
  summarise_at(vars(zRTTarget_trim), mean)
```

```
z_netdemask_rt_item = group_by(new_netdemask_z, ItemNumber, pathlength ) %>%
  summarise_at(vars(zRTTarget_trim), mean)

z_rmisc = Rmisc::summarySE(new_netdemask_z,
                        measurevar = "zRTTarget_trim",
                        groupvars = c("pathlength"))
```

Subject ANOVA

```
z_netdemask_rt$pathlengthfac = ordered(as.factor(as.character(z_netdemask_rt$pathlength)),
                            levels = c("1", "2", "3", "4", "6", "15"))
z_netdemask_rt$subject = as.factor(z_netdemask_rt$subject)

z_rt_aov = aov(data = z_netdemask_rt, zRTTarget_trim ~ pathlengthfac +
                     Error(subject/(pathlengthfac)))
summary(z_rt_aov)
```

```
##
## Error: subject
##           Df   Sum Sq  Mean Sq F value Pr(>F)
## Residuals 38 0.002238 5.89e-05
##
## Error: subject:pathlengthfac
##                Df Sum Sq Mean Sq F value Pr(>F)
## pathlengthfac   5  7.205  1.4410   53.85 <2e-16 ***
## Residuals     190  5.084  0.0268
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
options(contrasts = c('contr.sum', 'contr.poly'))
 library(lsmeans)
```

```
## Warning: package 'lsmeans' was built under R version 3.4.4
```

```
## The 'lsmeans' package is being deprecated.
## Users are encouraged to switch to 'emmeans'.
## See help('transition') for more information, including how
## to convert 'lsmeans' objects and scripts to work with 'emmeans'.
```

```
 library(multcomp)
```

```
## Loading required package: mvtnorm
```

```
## Warning: package 'mvtnorm' was built under R version 3.4.4
```

```
## Loading required package: survival
```

```
## Warning: package 'survival' was built under R version 3.4.4
```

```
## Loading required package: TH.data
```

```
## Warning: package 'TH.data' was built under R version 3.4.4
```

```
## Loading required package: MASS
```

```
## Warning: package 'MASS' was built under R version 3.4.4
```

```
##
## Attaching package: 'MASS'
```

```
## The following object is masked from 'package:dplyr':
##
##     select
```

```
##
## Attaching package: 'TH.data'
```

```
## The following object is masked from 'package:MASS':
##
##     geyser
```

```
 sem_lsm = lsmeans::lsmeans(z_rt_aov, c("pathlengthfac"))
 prime_effect = cld(sem_lsm, alpha = 0.05,
                 adjust = "tukey", details = TRUE)
 library(knitr)
kable(subset(prime_effect$comparisons,prime_effect$comparisons$p.value < 0.1 ))
```

	contrast	estimate	SE	df	t.ratio	p.value
1	2 - 1	0.2462460	0.0370445	190	6.647306	0.0000000
2	4 - 1	0.3729819	0.0370445	190	10.068489	0.0000000
3	4 - 2	0.1267360	0.0370445	190	3.421184	0.0097947
4	6 - 1	0.4411278	0.0370445	190	11.908057	0.0000000
5	6 - 2	0.1948818	0.0370445	190	5.260752	0.0000057
7	3 - 1	0.4659161	0.0370445	190	12.577208	0.0000000
8	3 - 2	0.2196702	0.0370445	190	5.929903	0.0000002
11	15 - 1	0.5221870	0.0370445	190	14.096216	0.0000000
12	15 - 2	0.2759410	0.0370445	190	7.448910	0.0000000
13	15 - 4	0.1492050	0.0370445	190	4.027727	0.0011323

Item ANOVA

```
z_netdemask_rt_item$pathlengthfac = ordered(as.factor(as.character(z_netdemask_rt_item$pathlength)),
                            levels = c("1", "2", "3", "4", "6", "15"))
z_netdemask_rt_item$ItemNumber = as.factor(z_netdemask_rt_item$ItemNumber)

z_rt_aov_item = aov(data = z_netdemask_rt_item,
                    zRTTarget_trim ~ pathlengthfac)
summary(z_rt_aov_item)
```

```
##                Df Sum Sq Mean Sq F value   Pr(>F)
## pathlengthfac   5   7.44  1.4876   10.23 7.05e-09 ***
## Residuals     234  34.04  0.1455
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

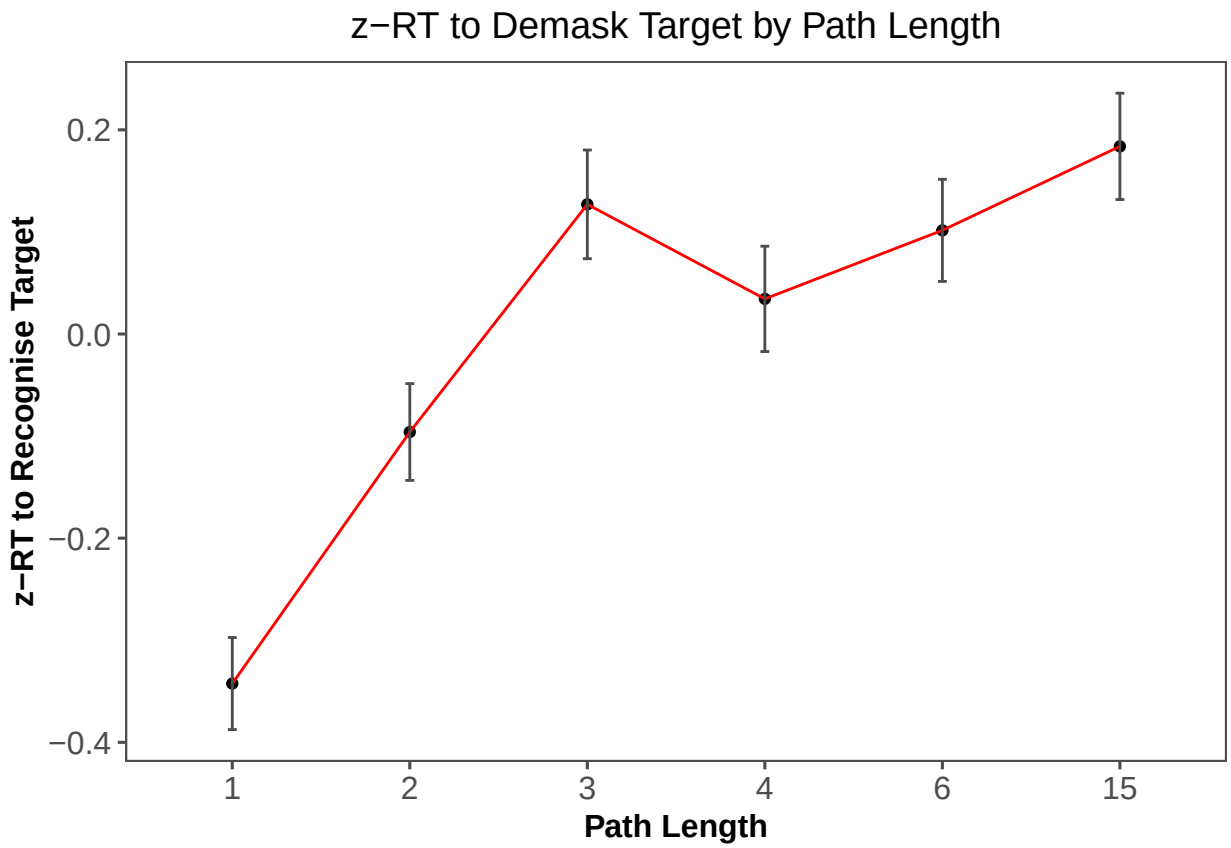
```
options(contrasts = c('contr.sum', 'contr.poly'))
 library(lsmeans)
 library(multcomp)
 sem_lsm = lsmeans::lsmeans(z_rt_aov_item, c("pathlengthfac"))
 prime_effect = cld(sem_lsm, alpha = 0.05,
                 adjust = "tukey", details = TRUE)
```

```
 library(knitr)
kable(subset(prime_effect$comparisons,prime_effect$comparisons$p.value < 0.1 ))
```

	contrast	estimate	SE	df	t.ratio	p.value
1	2 - 1	0.2403601	0.0852803	234	2.818471	0.0580345
2	4 - 1	0.3683890	0.0852803	234	4.319743	0.0003300
4	6 - 1	0.4401944	0.0852803	234	5.161736	0.0000077
7	3 - 1	0.4739788	0.0852803	234	5.557893	0.0000011
8	3 - 2	0.2336187	0.0852803	234	2.739421	0.0714565
11	15 - 1	0.5178251	0.0852803	234	6.072036	0.0000001
12	15 - 2	0.2774650	0.0852803	234	3.253565	0.0163090

Plotting RTs: collapsed

```
z_rmisc$pathlengthfac = ordered(as.factor(as.character(z_rmisc$pathlength)),

z_rmisc$zRTTarget_trim = as.numeric(z_rmisc$zRTTarget_trim)

library(ggplot2)
library(ggthemes)

z_rmisc %>%
  ggplot(aes(x = pathlengthfac, y = zRTTarget_trim, group = 1))+
  geom_point()+
#  geom_smooth(method = "loess")+
geom_line(color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - ci, ymax=zRTTarget_trim + ci),
              width=.05, color = "gray30",
              position = position_dodge(0.7))+
 theme_few()+
  #scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("z-RT to Recognise Target") +
  ggtitle("z-RT to Demask Target by Path Length")  +
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```

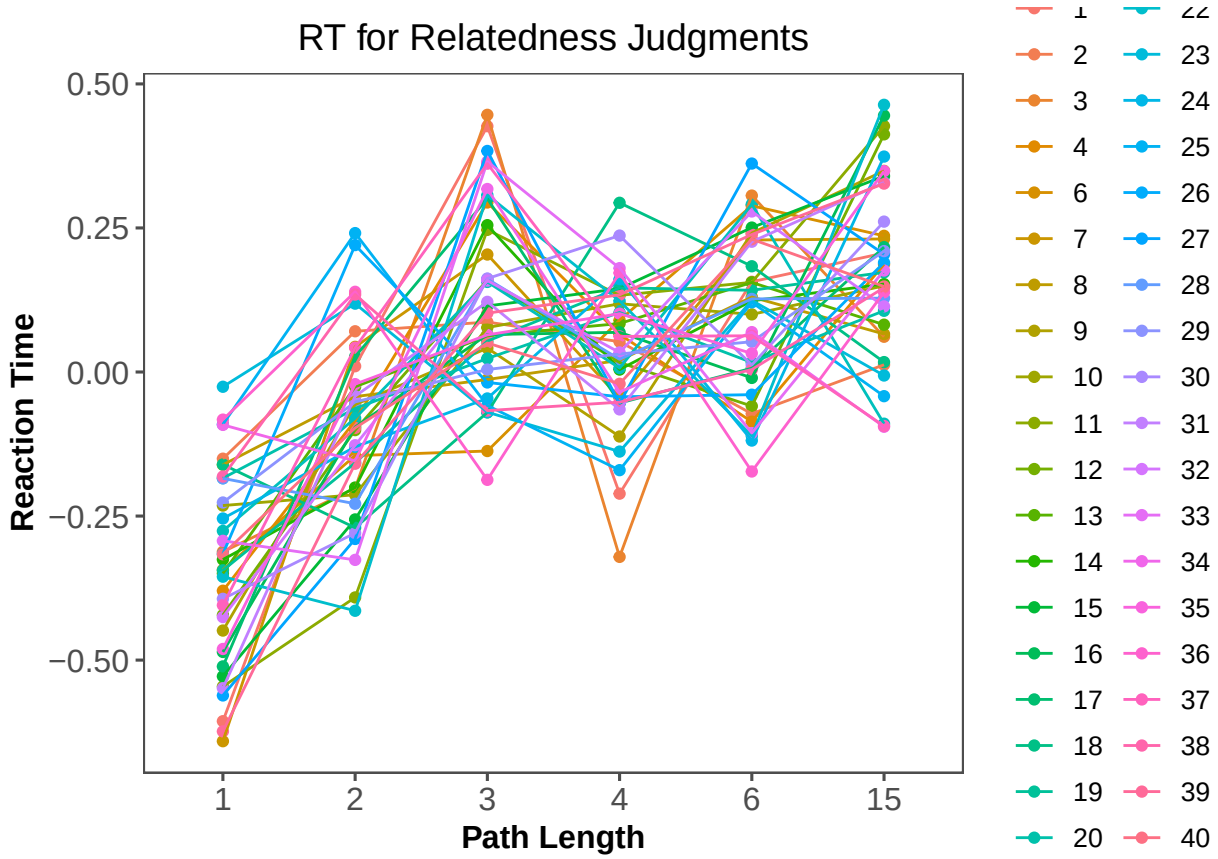



```
z_rmisc_kenett = z_rmisc
z_rmisc_kenett$Network = "Association Correlation"
```

Subject z RT

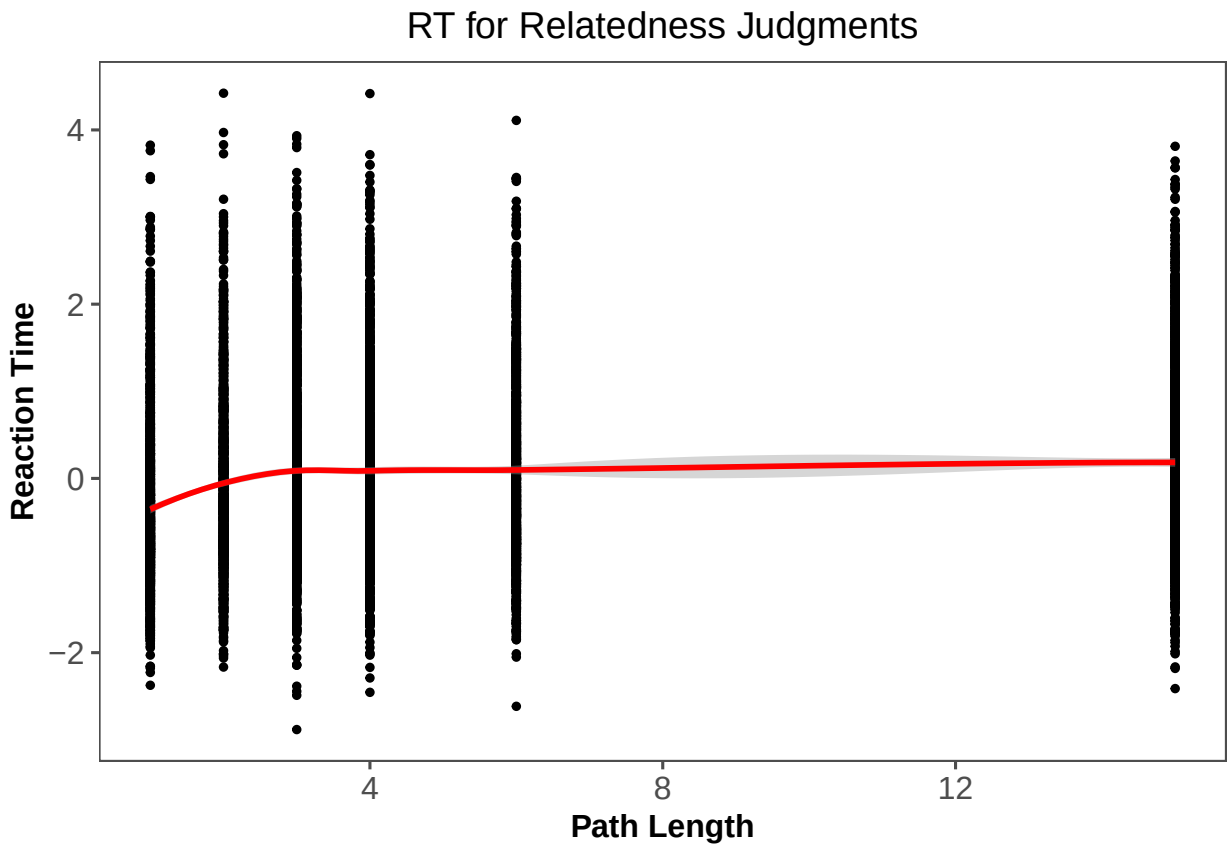
```
library(ggplot2)
library(ggthemes)


z_netdemask_rt %>%
  ggplot(aes(x = pathlengthfac, y = zRTTarget_trim,
             group = subject, color = subject))+
  geom_point()+
  geom_line()+
   #geom_errorbar(aes(ymin=Trials - ci, ymax=Trials + ci),
  #            width=.2, color = "gray26",
   #           position = position_dodge(0.7))+
 theme_few()+
  #guides(color = FALSE)+
#  scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("Reaction Time") +
  ggtitle("RT for Relatedness Judgments")  +
 # facet_wrap(~subject)+
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
```

```
        legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



Quadratic Trend?

```
new_netdemask_z %>%
  ggplot(aes(x = pathlength, y = zRTTarget_trim))+
 geom_point(color = "black", size = 1)+
  geom_smooth(method = "loess", color = "red")+
 theme_few()+
  #guides(color = FALSE)+
#  scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("Reaction Time") +
  ggtitle("RT for Relatedness Judgments")  +
 # facet_wrap(~subject)+
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



Concreteness Norms

```
elpnorms = read.csv("ELP_norms.csv", header = TRUE, sep = ",")

elpnorms = elpnorms[,c(1,2)]
normcount = elpnorms %>% group_by(Word) %>%
  summarize(n = n())
colnames(elpnorms) = c("prime_word", "prime_concreteness")
elpnorms$prime_word = toupper(elpnorms$prime_word)

elpnorms$prime_word = as.character(elpnorms$prime_word)

netdemask$prime_word = as.character(netdemask$prime_word)
merged_sem_prime= inner_join(netdemask, elpnorms, by = "prime_word")
merged_sem_prime = merged_sem_prime[,c(2,5, 20,28)]

colnames(elpnorms) = c("target_word", "target_concreteness")
netdemask$target_word = as.character(netdemask$target_word)
merged_sem_target= inner_join(netdemask, elpnorms, by = "target_word")
merged_sem_target = merged_sem_target[,c(2,5, 22,28)]

merged_concretness = full_join(merged_sem_prime, merged_sem_target,
                          by = c("Trial", "subject"))
merged_concretness$mean_conc = (merged_concretness$prime_concreteness +
```

```
                                merged_concretness$target_concreteness) / 2

### NOW WE HAVE CONCRETENESS NORMS FOR ALL ITEMS IN THE DATASET
### NEED TO COMBINE THIS WITH ACTUAL SEM DATA

new_netdemask_z$prime_word = as.character(new_netdemask_z$prime_word)
new_netdemask_z$target_word = as.character(new_netdemask_z$target_word)
final_netdemask_z = left_join(new_netdemask_z, merged_concretness,
                      by = c("Trial", "subject",
                             "prime_word", "target_word") )
```

Model

```
final_netdemask_z$mean_conc_c = scale(final_netdemask_z$mean_conc,
                                      center = TRUE, scale = FALSE)
final_netdemask_z$mean_conc_c = as.numeric(final_netdemask_z$mean_conc_c)

final_netdemask_z$mean_len_c = scale(final_netdemask_z$MeanLength,
                             center = TRUE, scale = FALSE)
final_netdemask_z$mean_logf_c = scale(final_netdemask_z$MeanLogF,
                              center = TRUE, scale = FALSE)
final_netdemask_z$mean_ldtz_c = scale(final_netdemask_z$MeanLDTZ,
                              center = TRUE, scale = FALSE)

final_netdemask_z$mean_len_c = as.numeric(final_netdemask_z$mean_len_c)
final_netdemask_z$mean_logf_c = as.numeric(final_netdemask_z$mean_logf_c)
final_netdemask_z$mean_ldtz_c = as.numeric(final_netdemask_z$mean_ldtz_c)

library(lme4)
```

```
## Warning: package 'lme4' was built under R version 3.4.4
```

```
## Loading required package: Matrix
```

```
## Warning: package 'Matrix' was built under R version 3.4.4
```

```
final_netdemask_z$pathlengthfac = ordered(as.factor(as.character(final_netdemask_z$pathlength)),

contrasts(final_netdemask_z$pathlengthfac) = contr.treatment(6, base = 3)


RTprime_model = lmer(data = final_netdemask_z,
                         zRTTarget_trim ~ pathlengthfac +
                        mean_len_c + mean_logf_c + mean_ldtz_c +
                          mean_conc_c +
                           (1|subject) + (1|ItemNumber))
summary(RTprime_model)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## zRTTarget_trim ~ pathlengthfac + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c + (1 | subject) + (1 | ItemNumber)
##    Data: final_netdemask_z
##
```

```
## REML criterion at convergence: 21609.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9037 -0.6839 -0.1567  0.5492  4.7953
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.08613  0.2935
##  subject    (Intercept) 0.00000  0.0000
##  Residual               0.83819  0.9155
## Number of obs: 7980, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##                 Estimate Std. Error t value
## (Intercept)     0.128291   0.056193   2.283
## pathlengthfac1 -0.497019   0.078634  -6.321
## pathlengthfac2 -0.260579   0.080530  -3.236
## pathlengthfac4 -0.067034   0.078371  -0.855
## pathlengthfac5 -0.010348   0.078807  -0.131
## pathlengthfac6  0.025703   0.078672   0.327
## mean_len_c      0.067180   0.014567   4.612
## mean_logf_c     0.006046   0.016683   0.362
## mean_ldtz_c     0.193301   0.130796   1.478
## mean_conc_c    -0.051419   0.029229  -1.759
##
## Correlation of Fixed Effects:
##             (Intr) pthln1 pthln2 pthln4 pthln5 pthln6 mn_ln_ mn_lg_ mn_ld_
## pthlngthfc1 -0.711
## pthlngthfc2 -0.704  0.500
## pthlngthfc4 -0.718  0.505  0.502
## pthlngthfc5 -0.719  0.504  0.505  0.520
## pthlngthfc6 -0.714  0.508  0.500  0.513  0.511
## mean_len_c  -0.003 -0.065 -0.054  0.065  0.081 -0.002
## mean_logf_c -0.028  0.031 -0.022  0.044  0.019  0.051  0.067
## mean_ldtz_c -0.067  0.080  0.071  0.022  0.060  0.051 -0.318  0.551
## mean_conc_c -0.084 -0.002  0.104  0.098  0.102  0.064  0.175  0.246  0.145
```

```
car::Anova(RTprime_model)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                 Chisq Df Pr(>Chisq)
## pathlengthfac 68.2168  5  2.407e-13 ***
## mean_len_c    21.2681  1  3.993e-06 ***
## mean_logf_c    0.1313  1    0.71705
## mean_ldtz_c    2.1841  1    0.13944
## mean_conc_c    3.0947  1    0.07855 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Quadratic Model

```
RTprime_model_linear = lmer(data = final_netdemask_z,
                            zRTTarget_trim ~  pathlength +
                           mean_len_c + mean_logf_c + mean_ldtz_c +
                             mean_conc_c +
                              (1|subject) + (1|ItemNumber))
summary(RTprime_model_linear)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## zRTTarget_trim ~ pathlength + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c + (1 | subject) + (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21640.1
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8823 -0.6826 -0.1564  0.5459  4.7780
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.1085   0.3294
##  subject    (Intercept) 0.0000   0.0000
##  Residual               0.8378   0.9153
## Number of obs: 7980, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) -0.132751   0.037038  -3.584
## pathlength   0.024521   0.005307   4.621
## mean_len_c   0.055631   0.015000   3.709
## mean_logf_c  0.008337   0.017297   0.482
## mean_ldtz_c  0.183643   0.136183   1.349
## mean_conc_c -0.060928   0.031575  -1.930
##
## Correlation of Fixed Effects:
##             (Intr) pthlng mn_ln_ mn_lg_ mn_ld_
## pathlength  -0.745
## mean_len_c  -0.030  0.048
## mean_logf_c -0.033  0.047  0.066
## mean_ldtz_c  0.002 -0.004 -0.310  0.553
## mean_conc_c -0.021  0.032  0.161  0.240  0.139
```

```
car::Anova(RTprime_model_linear)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##               Chisq Df Pr(>Chisq)
## pathlength  21.3518  1  3.823e-06 ***
## mean_len_c  13.7549  1  0.0002083 ***
## mean_logf_c  0.2323  1  0.6298325
```

```
## mean_ldtz_c  1.8185  1  0.1774952
## mean_conc_c  3.7234  1  0.0536541 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
final_netdemask_z$pquad = (final_netdemask_z$pathlength)^2

RTprime_model_quad = lmer(data = final_netdemask_z,
                          zRTTarget_trim ~ pathlength +
                            pquad +
                          mean_len_c + mean_logf_c + mean_ldtz_c +
                            mean_conc_c +
                            (1|subject) + (1|ItemNumber))
summary(RTprime_model_quad)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: zRTTarget_trim ~ pathlength + pquad + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c + (1 | subject) + (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21626.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9216 -0.6817 -0.1586  0.5448  4.7986
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.09122  0.3020
##  subject    (Intercept) 0.00000  0.0000
##  Residual               0.83837  0.9156
## Number of obs: 7980, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept) -0.415933   0.064612  -6.437
## pathlength   0.148387   0.024419   6.077
## pquad       -0.007396   0.001427  -5.181
## mean_len_c   0.067926   0.014714   4.616
## mean_logf_c  0.008073   0.016807   0.480
## mean_ldtz_c  0.214414   0.131786   1.627
## mean_conc_c -0.046824   0.029621  -1.581
##
## Correlation of Fixed Effects:
##             (Intr) pthlng pquad  mn_ln_ mn_lg_ mn_ld_
## pathlength  -0.908
## pquad        0.845 -0.979
## mean_len_c  -0.162  0.179 -0.173
## mean_logf_c -0.017  0.008  0.002  0.064
## mean_ldtz_c  0.035 -0.040  0.040 -0.317  0.554
## mean_conc_c -0.083  0.090 -0.085  0.177  0.248  0.139
```

```
car::Anova(RTprime_model_quad)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
```

```
##
## Response: zRTTarget_trim
##               Chisq Df Pr(>Chisq)
## pathlength  36.9260  1  1.227e-09 ***
## pquad       26.8476  1  2.201e-07 ***
## mean_len_c  21.3112  1  3.904e-06 ***
## mean_logf_c  0.2307  1     0.6310
## mean_ldtz_c  2.6471  1     0.1037
## mean_conc_c  2.4989  1     0.1139
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(RTprime_model_linear, RTprime_model_quad)
```

```
## refitting model(s) with ML (instead of REML)
```

```
## Data: final_netdemask_z
## Models:
## RTprime_model_linear: zRTTarget_trim ~ pathlength + mean_len_c + mean_logf_c + mean_ldtz_c +
## RTprime_model_linear:     mean_conc_c + (1 | subject) + (1 | ItemNumber)
## RTprime_model_quad: zRTTarget_trim ~ pathlength + pquad + mean_len_c + mean_logf_c +
## RTprime_model_quad:     mean_ldtz_c + mean_conc_c + (1 | subject) + (1 | ItemNumber)
##                      Df   AIC   BIC logLik deviance  Chisq Chi Df
## RTprime_model_linear  9 21623 21686 -10802    21605
## RTprime_model_quad   10 21599 21669 -10790    21579 25.649      1
##                      Pr(>Chisq)
## RTprime_model_linear
## RTprime_model_quad    4.095e-07 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Other Networks

Steyvers Non Directed

```
library(lme4)
final_netdemask_z$Undirected = as.double(as.character(final_netdemask_z$Undirected))
final_netdemask_z$Directed = as.double(as.character(final_netdemask_z$Directed))

final_netdemask_z$undirectedfac = ordered(as.factor(as.character(final_netdemask_z$Undirected)),


contrasts(final_netdemask_z$undirectedfac) = contr.treatment(4, base = 3)
RTprime_undirected = lmer(data = final_netdemask_z,
                          zRTTarget_trim ~ undirectedfac +
                            mean_len_c + mean_logf_c + mean_ldtz_c +
                           mean_conc_c +
                            (1|subject) + (1|ItemNumber))
summary(RTprime_undirected)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## zRTTarget_trim ~ undirectedfac + mean_len_c + mean_logf_c + mean_ldtz_c +
```

```
##     mean_conc_c + (1 | subject) + (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21616.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8990 -0.6816 -0.1576  0.5423  4.7711
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.09735  0.312
##  subject    (Intercept) 0.00000  0.000
##  Residual               0.83731  0.915
## Number of obs: 7980, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##                 Estimate Std. Error t value
## (Intercept)     0.103312   0.036458   2.834
## undirectedfac1 -0.485845   0.084388  -5.757
## undirectedfac2 -0.188318   0.052540  -3.584
## undirectedfac4  0.178984   0.092871   1.927
## mean_len_c      0.059112   0.014774   4.001
## mean_logf_c     0.008758   0.016985   0.516
## mean_ldtz_c     0.115447   0.134340   0.859
## mean_conc_c    -0.063815   0.030388  -2.100
##
## Correlation of Fixed Effects:
##             (Intr) undrc1 undrc2 undrc4 mn_ln_ mn_lg_ mn_ld_
## undirctdfc1 -0.435
## undirctdfc2 -0.699  0.304
## undirctdfc4 -0.394  0.163  0.271
## mean_len_c   0.099 -0.079 -0.108 -0.066
## mean_logf_c  0.003 -0.035  0.004  0.023  0.063
## mean_ldtz_c -0.038  0.070  0.061 -0.067 -0.315  0.546
## mean_conc_c  0.028  0.041 -0.066  0.020  0.163  0.242  0.137
```

```
car::Anova(RTprime_undirected)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                 Chisq Df Pr(>Chisq)
## undirectedfac 48.8164  3  1.427e-10 ***
## mean_len_c    16.0090  1  6.304e-05 ***
## mean_logf_c    0.2659  1    0.60612
## mean_ldtz_c    0.7385  1    0.39014
## mean_conc_c    4.4099  1    0.03573 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
RTprime_undirected_linear = lmer(data = final_netdemask_z,
                         zRTTarget_trim ~ Undirected +
                            mean_len_c + mean_logf_c + mean_ldtz_c +
                          mean_conc_c +
```

```
                            (1|subject) + (1|ItemNumber))

RTprime_undirected_quad = lmer(data = final_netdemask_z,
                           zRTTarget_trim ~ Undirected +
                             I(Undirected^2)+
                              mean_len_c + mean_logf_c + mean_ldtz_c +
                            mean_conc_c +
                             (1|subject) + (1|ItemNumber))
summary(RTprime_undirected_quad)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: zRTTarget_trim ~ Undirected + I(Undirected^2) + mean_len_c +
##     mean_logf_c + mean_ldtz_c + mean_conc_c + (1 | subject) +
##     (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21617
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9014 -0.6832 -0.1571  0.5405  4.7741
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.09665  0.3109
##  subject    (Intercept) 0.00000  0.0000
##  Residual               0.83737  0.9151
## Number of obs: 7980, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)     -0.699096   0.186997  -3.739
## Undirected       0.362447   0.156235   2.320
## I(Undirected^2) -0.030491   0.031214  -0.977
## mean_len_c       0.059733   0.014699   4.064
## mean_logf_c      0.008497   0.016957   0.501
## mean_ldtz_c      0.118525   0.134142   0.884
## mean_conc_c     -0.062817   0.030246  -2.077
##
## Correlation of Fixed Effects:
##             (Intr) Undrct I(U^2) mn_ln_ mn_lg_ mn_ld_
## Undirected  -0.967
## I(Undrct^2)  0.904 -0.980
## mean_len_c  -0.076  0.066 -0.053
## mean_logf_c -0.023  0.017 -0.010  0.066
## mean_ldtz_c  0.023  0.004 -0.028 -0.317  0.547
## mean_conc_c  0.058 -0.068  0.074  0.159  0.244  0.136
```

```
car::Anova(RTprime_undirected_quad)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                    Chisq Df Pr(>Chisq)
```

```
## Undirected       5.3819  1    0.02035 *
## I(Undirected^2)  0.9542  1    0.32864
## mean_len_c      16.5129  1  4.832e-05 ***
## mean_logf_c      0.2511  1    0.61631
## mean_ldtz_c      0.7807  1    0.37692
## mean_conc_c      4.3134  1    0.03781 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(RTprime_undirected_linear, RTprime_undirected_quad)
```

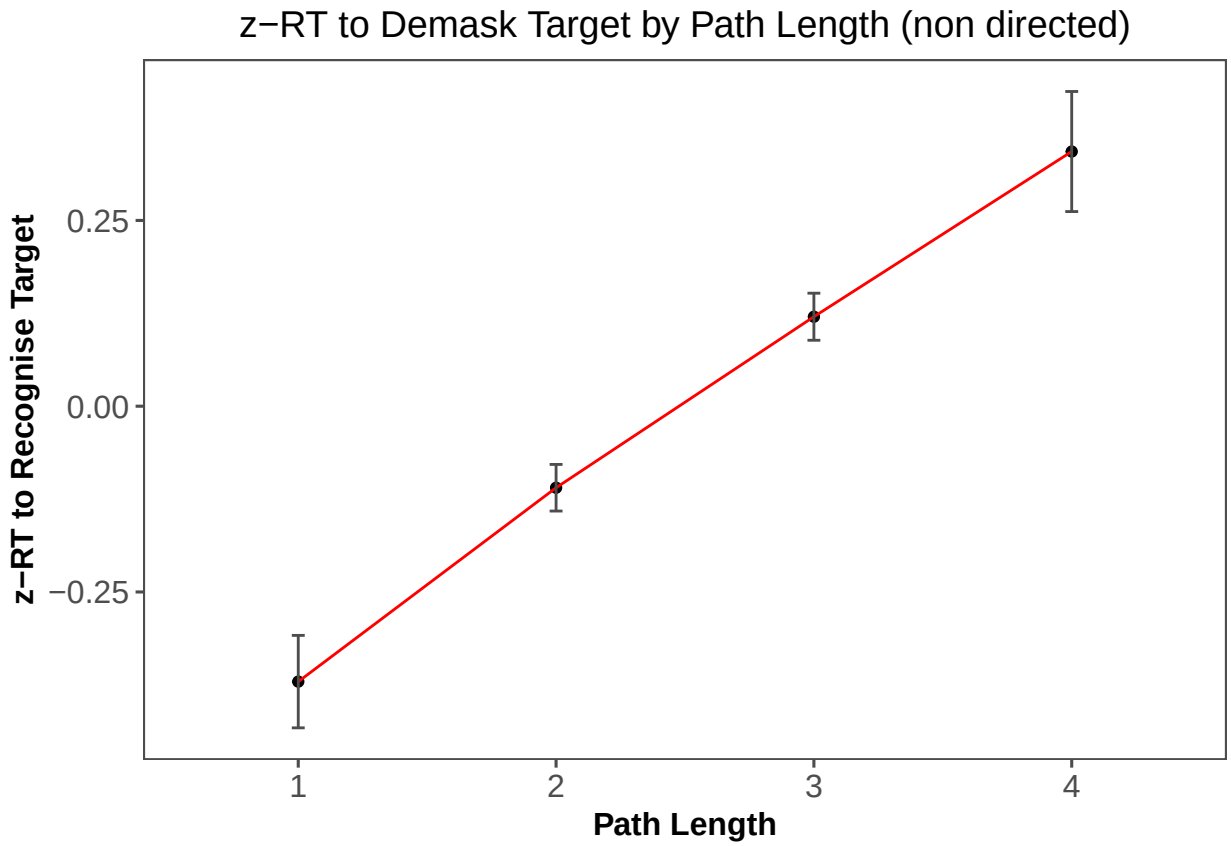
```
## refitting model(s) with ML (instead of REML)
```

```
## Data: final_netdemask_z
## Models:
## RTprime_undirected_linear: zRTTarget_trim ~ Undirected + mean_len_c + mean_logf_c + mean_ldtz_c +
## RTprime_undirected_linear:     mean_conc_c + (1 | subject) + (1 | ItemNumber)
## RTprime_undirected_quad: zRTTarget_trim ~ Undirected + I(Undirected^2) + mean_len_c +
## RTprime_undirected_quad:     mean_logf_c + mean_ldtz_c + mean_conc_c + (1 | subject) +
## RTprime_undirected_quad:     (1 | ItemNumber)
##                            Df   AIC   BIC logLik deviance  Chisq Chi Df
## RTprime_undirected_linear   9 21599 21662 -10790    21581
## RTprime_undirected_quad    10 21600 21670 -10790    21580 0.9862      1
##                            Pr(>Chisq)
## RTprime_undirected_linear
## RTprime_undirected_quad        0.3207
```

Plot

```
z_rmisc_undirected = Rmisc::summarySE(final_netdemask_z,
                        measurevar = "zRTTarget_trim",
                        groupvars = c("Undirected"))
z_rmisc_undirected = z_rmisc_undirected %>% filter(Undirected != "NA")
z_rmisc_undirected$undirectedfac = ordered(as.factor(as.character(z_rmisc_undirected$Undirected)),

z_rmisc_undirected$zRTTarget_trim = as.numeric(z_rmisc_undirected$zRTTarget_trim)

library(ggplot2)
library(ggthemes)

z_rmisc_undirected %>%
  ggplot(aes(x = undirectedfac, y = zRTTarget_trim, group = 1))+
  geom_point()+
#  geom_smooth(method = "loess")+
geom_line(color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - ci, ymax=zRTTarget_trim + ci),
             width=.05, color = "gray30",
             position = position_dodge(0.7))+
 theme_few()+
  #scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("z-RT to Recognise Target") +
  ggtitle("z-RT to Demask Target by Path Length (non directed)")  +
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
```

```
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```




```
z_rmisc_undirected$Network = "Undirected Simple Association"
```

Steyvers Directed

```
library(lme4)
final_netdemask_z$newdirected = ifelse(final_netdemask_z$Directed == "Inf" |
                               final_netdemask_z$Directed == "NA", NA,
                               final_netdemask_z$Directed)

final_netdemask_z$directedcollapsed = ifelse((final_netdemask_z$newdirected == "6" |final_netdemask_z$n


final_netdemask_z$directedfac =
  ordered(as.factor(as.character(final_netdemask_z$newdirected)),
                             levels = c("1", "2", "3", "4", "5",
                                        "6", "7", "8"))
contrasts(final_netdemask_z$directedfac) = contr.treatment(8, base = 5)

final_netdemask_z$collapsedfac =
  ordered(as.factor(as.character(final_netdemask_z$directedcollapsed)),
                             levels = c("1", "2", "3", "4","5", "H"))
```

```r
contrasts(final_netdemask_z$collapsedfac) = contr.treatment(6, base = 5)


RTprime_directed = lmer(data = final_netdemask_z,
                        zRTTarget_trim ~ collapsedfac +
                        mean_len_c + mean_logf_c + mean_ldtz_c +
                         mean_conc_c +
                          (1|subject) + (1|ItemNumber))
summary(RTprime_directed)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula:
## zRTTarget_trim ~ collapsedfac + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c + (1 | subject) + (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21089.4
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8934 -0.6838 -0.1555  0.5444  4.5192
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.09085  0.3014
##  subject    (Intercept) 0.00000  0.0000
##  Residual               0.82931  0.9107
## Number of obs: 7812, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##                Estimate Std. Error t value
## (Intercept)    0.087697   0.037941   2.311
## collapsedfac1 -0.338205   0.072760  -4.648
## collapsedfac2 -0.258417   0.049655  -5.204
## collapsedfac3 -0.146675   0.044294  -3.311
## collapsedfac4 -0.080752   0.040401  -1.999
## collapsedfac6  0.186354   0.058356   3.193
## mean_len_c     0.058082   0.014629   3.970
## mean_logf_c    0.009009   0.016992   0.530
## mean_ldtz_c    0.134190   0.133030   1.009
## mean_conc_c   -0.050336   0.029627  -1.699
##
## Correlation of Fixed Effects:
##             (Intr) cllps1 cllps2 cllps3 cllps4 cllps6 mn_ln_ mn_lg_ mn_ld_
## collapsdfc1 -0.465
## collapsdfc2 -0.610  0.400
## collapsdfc3 -0.643  0.374  0.530
## collapsdfc4 -0.690  0.399  0.520  0.578
## collapsdfc6 -0.468  0.273  0.396  0.365  0.443
## mean_len_c   0.068 -0.050 -0.082 -0.070 -0.050 -0.033
## mean_logf_c  0.061 -0.110 -0.049 -0.038 -0.059 -0.051  0.078
## mean_ldtz_c -0.022  0.059  0.041  0.042 -0.004 -0.020 -0.314  0.545
## mean_conc_c  0.031  0.006 -0.063 -0.053 -0.010  0.015  0.175  0.249  0.138
```

```
car::Anova(RTprime_directed)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                Chisq Df Pr(>Chisq)
## collapsedfac 74.2825  5  1.313e-14 ***
## mean_len_c   15.7639  1  7.176e-05 ***
## mean_logf_c   0.2811  1    0.59597
## mean_ldtz_c   1.0175  1    0.31311
## mean_conc_c   2.8866  1    0.08932 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
RTprime_directed_linear = lmer(data = final_netdemask_z,
                          zRTTarget_trim ~ newdirected +
                             mean_len_c + mean_logf_c + mean_ldtz_c +
                           mean_conc_c +
                            (1|subject) + (1|ItemNumber))

RTprime_directed_quad = lmer(data = final_netdemask_z,
                          zRTTarget_trim ~ newdirected +
                            I(newdirected^2)+
                             mean_len_c + mean_logf_c + mean_ldtz_c +
                           mean_conc_c +
                            (1|subject) + (1|ItemNumber))
summary(RTprime_directed_quad)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: zRTTarget_trim ~ newdirected + I(newdirected^2) + mean_len_c +
##     mean_logf_c + mean_ldtz_c + mean_conc_c + (1 | subject) +
##     (1 | ItemNumber)
##    Data: final_netdemask_z
##
## REML criterion at convergence: 21082.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.8941 -0.6828 -0.1569  0.5458  4.5567
##
## Random effects:
##  Groups     Name        Variance Std.Dev.
##  ItemNumber (Intercept) 0.09012  0.3002
##  subject    (Intercept) 0.00000  0.0000
##  Residual               0.82905  0.9105
## Number of obs: 7812, groups:  ItemNumber, 215; subject, 39
##
## Fixed effects:
##                   Estimate Std. Error t value
## (Intercept)      -0.299916   0.086567  -3.465
## newdirected       0.058395   0.045549   1.282
## I(newdirected^2)  0.004745   0.005795   0.819
## mean_len_c        0.056804   0.014593   3.892
## mean_logf_c       0.008904   0.016919   0.526
```

```
## mean_ldtz_c       0.138579   0.132737   1.044
## mean_conc_c      -0.050743   0.029458  -1.723
##
## Correlation of Fixed Effects:
##             (Intr) nwdrct I(n^2) mn_ln_ mn_lg_ mn_ld_
## newdirected -0.934
## I(nwdrct^2)  0.849 -0.971
## mean_len_c  -0.071  0.069 -0.057
## mean_logf_c -0.081  0.079 -0.069  0.080
## mean_ldtz_c  0.063 -0.050  0.032 -0.315  0.545
## mean_conc_c -0.018  0.006  0.008  0.172  0.255  0.139
```

```
car::Anova(RTprime_directed_quad)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                     Chisq Df Pr(>Chisq)
## newdirected        1.6436  1    0.19983
## I(newdirected^2)   0.6704  1    0.41291
## mean_len_c        15.1510  1  9.925e-05 ***
## mean_logf_c        0.2770  1    0.59871
## mean_ldtz_c        1.0900  1    0.29648
## mean_conc_c        2.9671  1    0.08497 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(RTprime_directed_linear, RTprime_directed_quad)
```

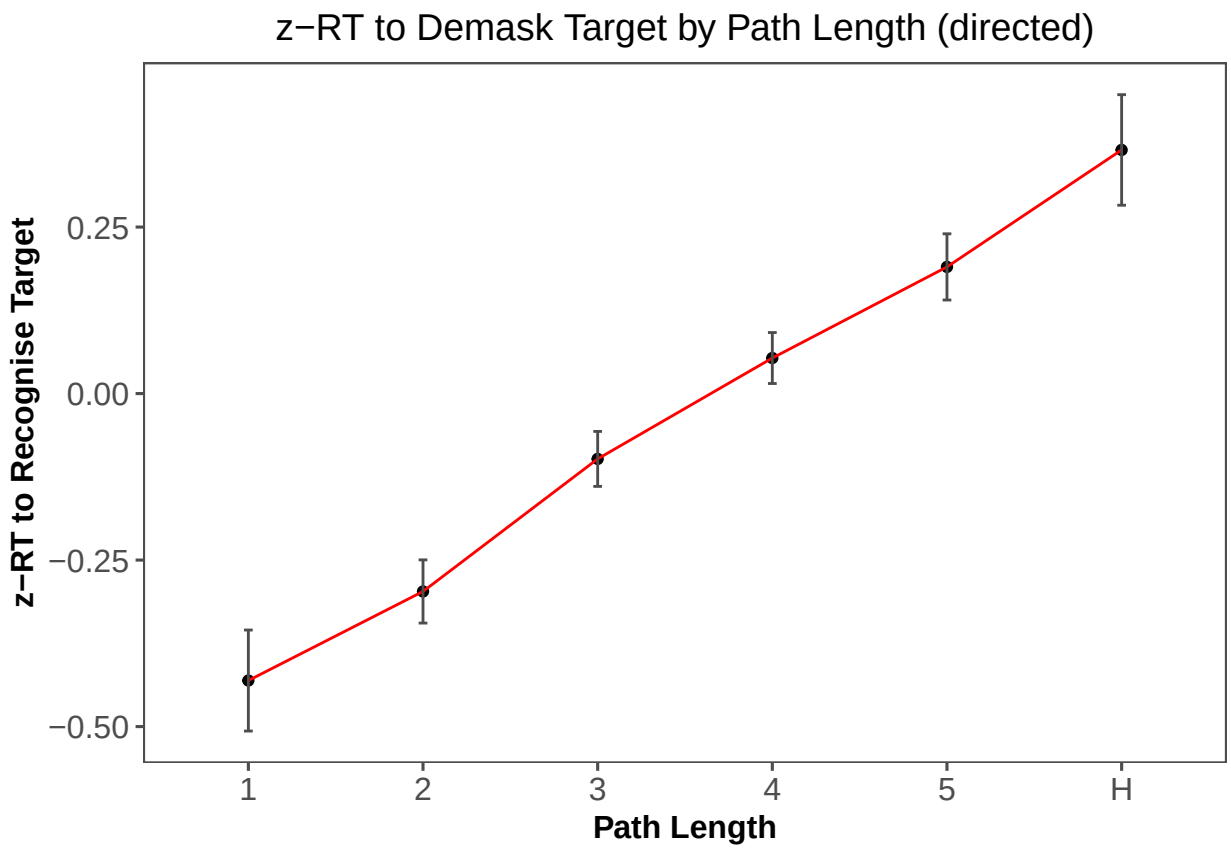
```
## refitting model(s) with ML (instead of REML)
```

```
## Data: final_netdemask_z
## Models:
## RTprime_directed_linear: zRTTarget_trim ~ newdirected + mean_len_c + mean_logf_c + mean_ldtz_c +
## RTprime_directed_linear:     mean_conc_c + (1 | subject) + (1 | ItemNumber)
## RTprime_directed_quad: zRTTarget_trim ~ newdirected + I(newdirected^2) + mean_len_c +
## RTprime_directed_quad:     mean_logf_c + mean_ldtz_c + mean_conc_c + (1 | subject) +
## RTprime_directed_quad:     (1 | ItemNumber)
##                          Df   AIC   BIC logLik deviance  Chisq Chi Df
## RTprime_directed_linear  9 21059 21121 -10520    21041
## RTprime_directed_quad   10 21060 21130 -10520    21040 0.6119      1
##                          Pr(>Chisq)
## RTprime_directed_linear
## RTprime_directed_quad       0.4341
```

Plot Collapsed

```
z_rmisc_directed = Rmisc::summarySE(final_netdemask_z,
                        measurevar = "zRTTarget_trim",
                        groupvars = c("collapsedfac"))
z_rmisc_directed = z_rmisc_directed %>% filter(collapsedfac != "NA")
z_rmisc_directed$collapsedfac2 = ordered(as.factor(as.character(z_rmisc_directed$collapsedfac)),

z_rmisc_directed$zRTTarget_trim = as.numeric(z_rmisc_directed$zRTTarget_trim)
```

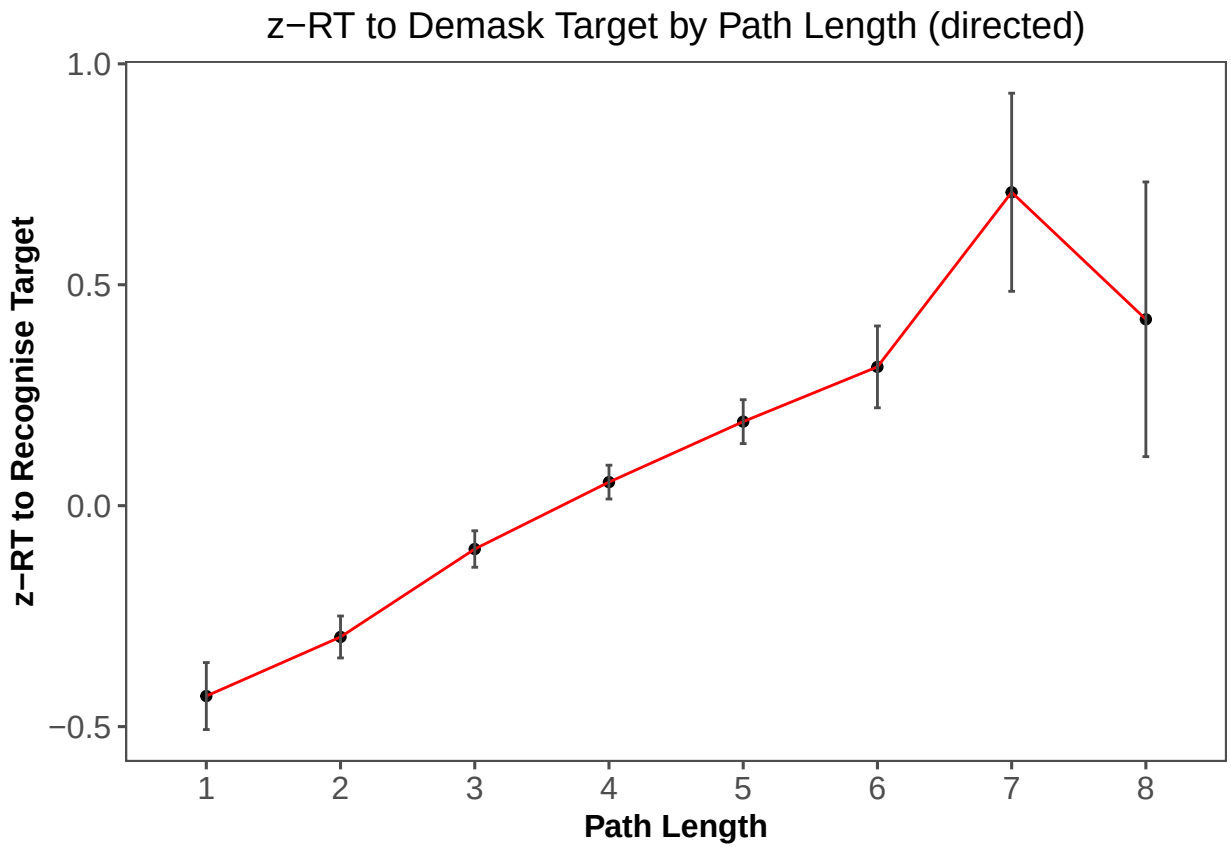
```r
z_rmisc_directed_collapsed = z_rmisc_directed

library(ggplot2)
library(ggthemes)

z_rmisc_directed_collapsed %>%
  ggplot(aes(x = collapsedfac2, y = zRTTarget_trim, group = 1))+
  geom_point()+
#  geom_smooth(method = "loess")+
geom_line(color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - ci, ymax=zRTTarget_trim + ci),
              width=.05, color = "gray30",
              position = position_dodge(0.7))+
 theme_few()+
  #scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("z-RT to Recognise Target") +
  ggtitle("z-RT to Demask Target by Path Length (directed)")  +
   theme(axis.text = element_text(size = rel(1)),
          axis.title = element_text(face = "bold", size = rel(1)),
          legend.title = element_text(face = "bold", size = rel(1)),
         plot.title = element_text(hjust = .5),
         strip.text.x = element_text(face = "bold", size = rel(1.4)))
```




```r
z_rmisc_directed_collapsed$Network = "Directed Simple Association"
```

Plot Not Collapsed

```
z_rmisc_directed = Rmisc::summarySE(final_netdemask_z,
                        measurevar = "zRTTarget_trim",
                        groupvars = c("directedfac"))
z_rmisc_directed = z_rmisc_directed %>% filter(directedfac != "NA")
z_rmisc_directed$collapsedfac2 = ordered(as.factor(as.character(z_rmisc_directed$directedfac)),

z_rmisc_directed$zRTTarget_trim = as.numeric(z_rmisc_directed$zRTTarget_trim)

library(ggplot2)
library(ggthemes)

z_rmisc_directed %>%
  ggplot(aes(x = collapsedfac2, y = zRTTarget_trim, group = 1))+
  geom_point()+
#  geom_smooth(method = "loess")+
geom_line(color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - ci, ymax=zRTTarget_trim + ci),
              width=.05, color = "gray30",
              position = position_dodge(0.7))+
 theme_few()+
  #scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Path Length") + ylab("z-RT to Recognise Target") +
  ggtitle("z-RT to Demask Target by Path Length (directed)")  +
   theme(axis.text = element_text(size = rel(1)),
          axis.title = element_text(face = "bold", size = rel(1)),
          legend.title = element_text(face = "bold", size = rel(1)),
         plot.title = element_text(hjust = .5),
         strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



LSA and word2vec

```
word2vec = read.csv("e3_word2vec.csv", header = TRUE, sep = ",")
## now word2vec contains both sided info, i.e., S1 and S2

final_word2vec = inner_join(final_netdemask_z, word2vec,
                        by = c("target_word", "Procedure", "prime_word"))
```

```
## Warning: Column `target_word` joining character vector and factor, coercing
## into character vector
```

```
## Warning: Column `prime_word` joining character vector and factor, coercing
## into character vector
```

```
## britannica is excluded
final_word2vec = final_word2vec %>% arrange(subject, Stimuli1)

mean_cosines =  group_by(final_word2vec,Procedure, ItemNumber) %>%
  summarise_at(vars(Undirected, Directed, pathlength, word2veccosine,
                    LSA), mean)

mean_cosines$newdirected = ifelse(mean_cosines$Directed == "Inf" |
                            mean_cosines$Directed == "NA", NA,
                          mean_cosines$Directed)

Hmisc::rcorr(as.matrix(mean_cosines[,c(3,6)]))$r
```

```
##                Undirected word2veccosine
## Undirected      1.0000000     -0.5480093
## word2veccosine -0.5480093      1.0000000
```

z-scoring measures

```
final_word2vec$zUndirected = as.numeric(scale(final_word2vec$Undirected,
                                              center = TRUE, scale = TRUE))

final_word2vec$zword2vec = as.numeric(scale(final_word2vec$word2veccosine,
                                              center = TRUE, scale = TRUE))

final_word2vec$zLSA = as.numeric(scale(final_word2vec$LSA,
                                              center = TRUE, scale = TRUE))

final_word2vec$zDirected = as.numeric(scale(final_word2vec$newdirected,
                                              center = TRUE, scale = TRUE))

final_word2vec$zKenett = as.numeric(scale(final_word2vec$pathlength,
                                              center = TRUE, scale = TRUE))
```

LSA

Continuous Model

```
model_lsa_cont  = lmer(data = final_word2vec,
                              zRTTarget_trim ~ LSA +
                       mean_len_c + mean_logf_c + mean_ldtz_c + mean_conc_c +
           (1|subject) + (1|Trial) +
              + (1|Pair))
 summary(model_lsa_cont)
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: zRTTarget_trim ~ LSA + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c + (1 | subject) + (1 | Trial) + +(1 | Pair)
##    Data: final_word2vec
##
## REML criterion at convergence: 21036.8
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9917 -0.6445 -0.1446  0.5249  4.5207
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Pair     (Intercept) 0.15112  0.3887
##  Trial    (Intercept) 0.02715  0.1648
##  subject  (Intercept) 0.00000  0.0000
##  Residual             0.74161  0.8612
## Number of obs: 7942, groups:  Pair, 426; Trial, 240; subject, 39
```

```
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  0.175813   0.031710   5.544
## LSA         -1.220335   0.146232  -8.345
## mean_len_c   0.044310   0.017433   2.542
## mean_logf_c  0.001432   0.021034   0.068
## mean_ldtz_c  0.619976   0.159926   3.877
## mean_conc_c -0.060828   0.027923  -2.178
##
## Correlation of Fixed Effects:
##             (Intr) LSA    mn_ln_ mn_lg_ mn_ld_
## LSA         -0.664
## mean_len_c   0.053 -0.077
## mean_logf_c  0.010 -0.009  0.057
## mean_ldtz_c -0.093  0.148 -0.366  0.559
## mean_conc_c  0.008 -0.004  0.186  0.317  0.179
```

```
car::Anova(model_lsa_cont)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##               Chisq Df Pr(>Chisq)
## LSA         69.6422  1  < 2.2e-16 ***
## mean_len_c   6.4607  1  0.0110287 *
## mean_logf_c  0.0046  1  0.9457386
## mean_ldtz_c 15.0284  1  0.0001059 ***
## mean_conc_c  4.7455  1  0.0293759 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Quintile Figure

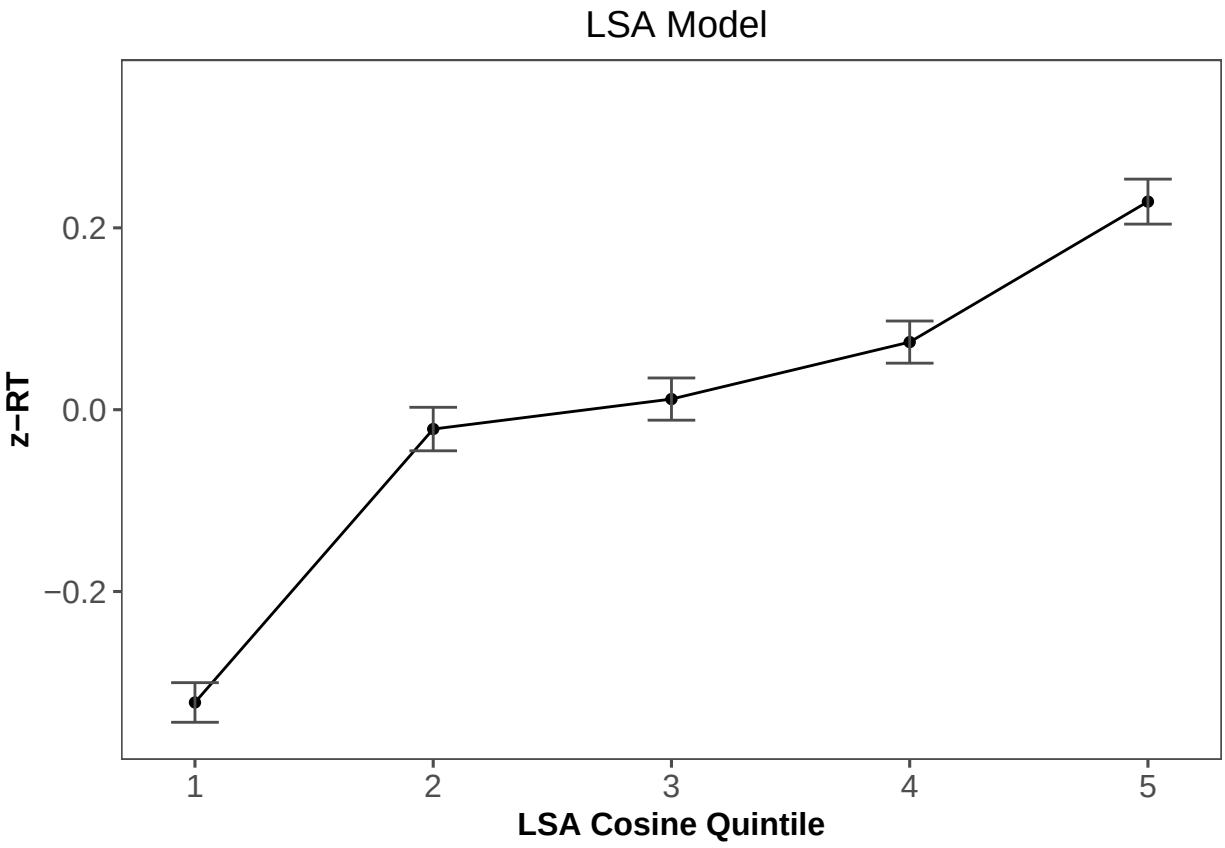
```
final_word2vec = final_word2vec %>%
    mutate(LSAquintile = ntile(zLSA, 5))

lsa_quintile_means = Rmisc::summarySE(final_word2vec,
                                      measurevar = "zRTTarget_trim",
                                      groupvars = c("LSAquintile"))

lsa_quintile_means$reversequintile = 6-lsa_quintile_means$LSAquintile
lsa_quintile_means %>%
ggplot(aes(x = reversequintile, y = zRTTarget_trim))+
geom_point()+
geom_line()+
  ylim(-0.35, 0.35)+
   geom_errorbar(aes(ymin=zRTTarget_trim - se, ymax=zRTTarget_trim + se),
              width=.2, color = "gray30",
              position = position_dodge(0.05))+
  theme_few()+
  scale_color_wsj()+
    xlab("LSA Cosine Quintile") + ylab("z-RT") +
```

```
  ggtitle(" LSA Model")  +
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```

```
## Warning: Removed 1 rows containing missing values (geom_path).
```

```
## Warning: Removed 1 rows containing missing values (geom_errorbar).
```



Categorical Model

```
final_word2vec_lsa_success = final_word2vec

final_word2vec_lsa_success$LSAquintilefac= ordered(as.factor(as.character(final_word2vec_lsa_success$LS
                           levels = c("1", "2", "3", "4", "5"))

contrasts(final_word2vec_lsa_success$LSAquintilefac) = contr.treatment(5, base = 3)
library(lmerTest)
```

```
## Warning: package 'lmerTest' was built under R version 3.4.4
```

```
##
## Attaching package: 'lmerTest'
```

```
## The following object is masked from 'package:lme4':
##
```

```
##     lmer
## The following object is masked from 'package:stats':
##
##     step
```

```
model_lsa  = lmer(data = final_word2vec_lsa_success,
                            zRTTarget_trim ~ LSAquintilefac +
                    mean_len_c + mean_logf_c + mean_ldtz_c + mean_conc_c +
          (1|subject) + (1|Trial) +
             + (1|Pair))
 summary(model_lsa)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: zRTTarget_trim ~ LSAquintilefac + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c + (1 | subject) + (1 | Trial) +
##     +(1 | Pair)
##    Data: final_word2vec_lsa_success
##
## REML criterion at convergence: 21056.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9859 -0.6442 -0.1459  0.5278  4.5196
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Pair     (Intercept) 0.15478  0.3934
##  Trial    (Intercept) 0.02722  0.1650
##  subject  (Intercept) 0.00000  0.0000
##  Residual             0.74167  0.8612
## Number of obs: 7942, groups:  Pair, 426; Trial, 240; subject, 39
##
## Fixed effects:
##                   Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)       0.050456   0.045132 651.878877   1.118   0.2640
## LSAquintilefac1   0.131986   0.063719 606.593772   2.071   0.0387 *
## LSAquintilefac2  -0.008869   0.059728 846.605812  -0.148   0.8820
## LSAquintilefac4  -0.016207   0.060831 654.988895  -0.266   0.7900
## LSAquintilefac5  -0.378014   0.065728 480.763412  -5.751 1.58e-08 ***
## mean_len_c        0.039055   0.017595 406.849321   2.220   0.0270 *
## mean_logf_c      -0.006540   0.021370 403.417171  -0.306   0.7597
## mean_ldtz_c       0.671975   0.161602 412.529700   4.158 3.90e-05 ***
## mean_conc_c      -0.067781   0.028724 409.886092  -2.360   0.0188 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) LSAqn1 LSAqn2 LSAqn4 LSAqn5 mn_ln_ mn_lg_ mn_ld_
## LSAquntlfc1 -0.678
## LSAquntlfc2 -0.659  0.545
## LSAquntlfc4 -0.640  0.448  0.441
## LSAquntlfc5 -0.648  0.462  0.453  0.441
## mean_len_c   0.036  0.005 -0.041 -0.048 -0.042
```

```
## mean_logf_c  0.003  0.019  0.016 -0.073  0.037  0.058
## mean_ldtz_c  0.045 -0.123 -0.025 -0.020  0.022 -0.361  0.556
## mean_conc_c  0.140 -0.161 -0.173 -0.074 -0.093  0.186  0.303  0.191
```

```
car::Anova(model_lsa)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                  Chisq Df Pr(>Chisq)
## LSAquintilefac 62.5145  4  8.586e-13 ***
## mean_len_c      4.9270  1    0.02644 *
## mean_logf_c     0.0937  1    0.75958
## mean_ldtz_c    17.2908  1  3.207e-05 ***
## mean_conc_c     5.5686  1    0.01829 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

word2vec

Continuous Model

```
model_word2vec_cont  = lmer(data = final_word2vec,
                            zRTTarget_trim ~ word2veccosine +
                     mean_len_c + mean_logf_c + mean_ldtz_c + mean_conc_c +
          (1|subject) + (1|Trial) +
             + (1|Pair))
summary(model_word2vec_cont)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: zRTTarget_trim ~ word2veccosine + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c + (1 | subject) + (1 | Trial) +
##     +(1 | Pair)
##    Data: final_word2vec
##
## REML criterion at convergence: 21123.3
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9786 -0.6462 -0.1384  0.5150  4.5720
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Pair     (Intercept) 0.14300  0.3782
##  Trial    (Intercept) 0.02783  0.1668
##  subject  (Intercept) 0.00000  0.0000
##  Residual             0.74172  0.8612
## Number of obs: 7980, groups:  Pair, 428; Trial, 240; subject, 39
##
## Fixed effects:
##                  Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)      0.214622   0.032413 475.151144   6.621 9.64e-11 ***
## word2veccosine  -1.347569   0.141638 406.480538  -9.514  < 2e-16 ***
```

```
## mean_len_c       0.037052   0.016802 410.264803   2.205    0.028 *
## mean_logf_c     -0.007069   0.020592 407.118244  -0.343    0.732
## mean_ldtz_c      0.741838   0.154538 414.610186   4.800 2.21e-06 ***
## mean_conc_c     -0.042363   0.027384 408.324271  -1.547    0.123
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) wrd2vc mn_ln_ mn_lg_ mn_ld_
## word2veccsn -0.694
## mean_len_c   0.031 -0.032
## mean_logf_c -0.020  0.034  0.054
## mean_ldtz_c -0.037  0.056 -0.354  0.570
## mean_conc_c  0.055 -0.073  0.196  0.314  0.175
```

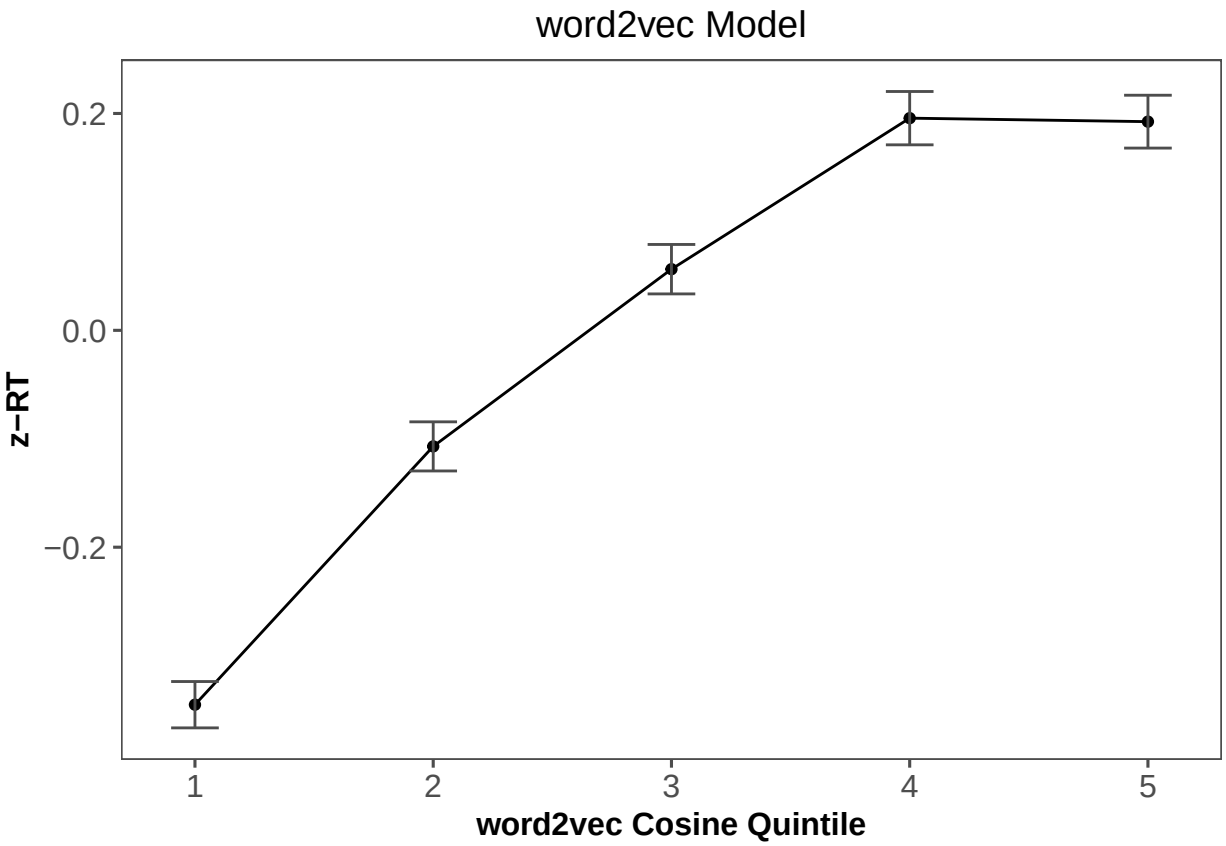
```
car::Anova(model_word2vec_cont)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                   Chisq Df Pr(>Chisq)
## word2veccosine 90.5196  1  < 2.2e-16 ***
## mean_len_c      4.8629  1    0.02744 *
## mean_logf_c     0.1178  1    0.73139
## mean_ldtz_c    23.0434  1  1.584e-06 ***
## mean_conc_c     2.3932  1    0.12186
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Quintile Figure

```
final_word2vec = final_word2vec %>%
    mutate(word2vecquintile = ntile(zword2vec, 5))

word2vec_quintile_means = Rmisc::summarySE(final_word2vec,
                                   measurevar = "zRTTarget_trim",
                                   groupvars = c("word2vecquintile"))

word2vec_quintile_means$reversecosine = 6 - word2vec_quintile_means$word2vecquintile
word2vec_quintile_means %>%
ggplot(aes(x = reversecosine, y = zRTTarget_trim))+
geom_point()+
geom_line()+
 # ylim(-0.35,0.35)+
   geom_errorbar(aes(ymin=zRTTarget_trim - se, ymax=zRTTarget_trim + se),
              width=.2, color = "gray30",
              position = position_dodge(0.05))+
  theme_few()+
  scale_color_wsj()+
    xlab("word2vec Cosine Quintile") + ylab("z-RT") +
  ggtitle("word2vec Model")  +
   theme(axis.text = element_text(size = rel(1)),
         axis.title = element_text(face = "bold", size = rel(1)),
```

```
         legend.title = element_text(face = "bold", size = rel(1)),
        plot.title = element_text(hjust = .5),
        strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



Model

```
final_word2vec_success = final_word2vec

final_word2vec_success$word2vecquintilefac= ordered(as.factor(as.character(final_word2vec_success$word2

contrasts(final_word2vec_success$word2vecquintilefac) =
  contr.treatment(5, base = 1)
model_word2vec  = lmer(data = final_word2vec_success,
                               zRTTarget_trim ~ word2vecquintilefac +
                      mean_len_c + mean_logf_c + mean_ldtz_c + mean_conc_c +
           (1|subject) + (1|Trial) +
              + (1|Pair))
 summary(model_word2vec)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula:
## zRTTarget_trim ~ word2vecquintilefac + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c + (1 | subject) + (1 | Trial) +
##     +(1 | Pair)
##    Data: final_word2vec_success
##
## REML criterion at convergence: 21136.2
```

```
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.9955 -0.6453 -0.1414  0.5168  4.5888
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  Pair     (Intercept) 0.14390  0.3793
##  Trial    (Intercept) 0.02782  0.1668
##  subject  (Intercept) 0.00000  0.0000
##  Residual             0.74175  0.8613
## Number of obs: 7980, groups:  Pair, 428; Trial, 240; subject, 39
##
## Fixed effects:
##                          Estimate Std. Error         df t value Pr(>|t|)
## (Intercept)            1.812e-01  4.659e-02  4.675e+02   3.890 0.000115 ***
## word2vecquintilefac2 -3.391e-04  6.516e-02  4.669e+02  -0.005 0.995849
## word2vecquintilefac3 -9.211e-02  6.417e-02  4.347e+02  -1.435 0.151893
## word2vecquintilefac4 -2.923e-01  6.481e-02  4.339e+02  -4.510 8.35e-06 ***
## word2vecquintilefac5 -5.177e-01  6.495e-02  4.247e+02  -7.971 1.47e-14 ***
## mean_len_c             3.418e-02  1.701e-02  4.081e+02   2.009 0.045148 *
## mean_logf_c           -9.146e-03  2.073e-02  4.048e+02  -0.441 0.659374
## mean_ldtz_c            7.639e-01  1.556e-01  4.125e+02   4.909 1.32e-06 ***
## mean_conc_c           -3.241e-02  2.776e-02  4.062e+02  -1.168 0.243676
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr) wrd2v2 wrd2v3 wrd2v4 wrd2v5 mn_ln_ mn_lg_ mn_ld_
## wrd2vcqntl2 -0.665
## wrd2vcqntl3 -0.691  0.494
## wrd2vcqntl4 -0.683  0.480  0.503
## wrd2vcqntl5 -0.680  0.478  0.486  0.500
## mean_len_c  -0.077  0.063  0.137  0.065  0.033
## mean_logf_c -0.005  0.022 -0.019 -0.031  0.058  0.048
## mean_ldtz_c  0.041 -0.053 -0.044 -0.071  0.023 -0.356  0.571
## mean_conc_c  0.012 -0.007  0.083 -0.044 -0.072  0.205  0.303  0.170
```

```
car::Anova(model_word2vec)
```

```
## Analysis of Deviance Table (Type II Wald chisquare tests)
##
## Response: zRTTarget_trim
##                        Chisq Df Pr(>Chisq)
## word2vecquintilefac 90.7465  4  < 2.2e-16 ***
## mean_len_c           4.0379  1    0.04449 *
## mean_logf_c          0.1946  1    0.65914
## mean_ldtz_c         24.0934  1  9.177e-07 ***
## mean_conc_c          1.3632  1    0.24299
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model Comparison Approach

Item Level

```
## at the item level, each word has a cosine and path
final_word2vec_complete = final_word2vec[which(!is.na(final_word2vec$directedcollapsed) & !is.na(final_v

final_item = group_by(final_word2vec_complete,
                      Pair, Procedure, prime_word, target_word) %>%
  summarize_at(vars(word2veccosine, LSA, Undirected, newdirected, pathlength,
                    zRTTarget_trim,
                    mean_len_c, mean_logf_c ,mean_ldtz_c, mean_conc_c), mean)

final_item$directedcollapsed = ifelse((final_item$newdirected == "6" |final_item$newdirected == "7" | fi

final_item$directedcollapsed = as.factor(final_item$directedcollapsed)
final_item$undirectedfac = as.factor(final_item$Undirected)
final_item$kenettfac = as.factor(final_item$pathlength)
final_item$directedfac = as.factor(final_item$newdirected)

## use same dataset for everyone

x = final_item[which(!is.na(final_item$directedcollapsed) & !is.na(final_item$mean_conc_c)),]
```

Cat-Cont Model

```
final_item_unconditional = lm(data = x,
                              zRTTarget_trim ~ 1 +
                                mean_len_c+ mean_logf_c +
                                mean_ldtz_c + mean_conc_c)
 summary(final_item_unconditional)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ 1 + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.97637 -0.36323 -0.05081  0.28215  1.90365
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.0083252  0.0231882  -0.359   0.7198
## mean_len_c   0.0341657  0.0190024   1.798   0.0729 .
## mean_logf_c -0.0004222  0.0230441  -0.018   0.9854
## mean_ldtz_c  0.7595262  0.1743584   4.356 1.67e-05 ***
## mean_conc_c -0.0615092  0.0303489  -2.027   0.0433 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4722 on 410 degrees of freedom
```

```
## Multiple R-squared:  0.1332, Adjusted R-squared:  0.1248
## F-statistic: 15.75 on 4 and 410 DF,  p-value: 5.279e-12
```

```
 ## r2 = 0.1333

final_item_undirected = lm(data = x,
                           zRTTarget_trim ~ 1 + undirectedfac +
                          mean_len_c+ mean_logf_c +
                            mean_ldtz_c + mean_conc_c)
 summary(final_item_undirected)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ 1 + undirectedfac + mean_len_c +
##     mean_logf_c + mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.88762 -0.34072 -0.05649  0.27682  2.02234
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)    -0.025659   0.028929  -0.887 0.375610
## undirectedfac1 -0.320903   0.057834  -5.549 5.19e-08 ***
## undirectedfac2 -0.061287   0.038445  -1.594 0.111676
## undirectedfac3  0.123913   0.037798   3.278 0.001134 **
## mean_len_c      0.047032   0.018264   2.575 0.010374 *
## mean_logf_c     0.007078   0.021970   0.322 0.747482
## mean_ldtz_c     0.602446   0.167662   3.593 0.000367 ***
## mean_conc_c    -0.057546   0.028999  -1.984 0.047877 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4492 on 407 degrees of freedom
## Multiple R-squared:  0.2216, Adjusted R-squared:  0.2082
## F-statistic: 16.55 on 7 and 407 DF,  p-value: < 2.2e-16
```

```
 anova(final_item_unconditional, final_item_undirected)
```

```
## Analysis of Variance Table
##
## Model 1: zRTTarget_trim ~ 1 + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c
## Model 2: zRTTarget_trim ~ 1 + undirectedfac + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1    410 91.434
## 2    407 82.110  3    9.3244 15.406 1.639e-09 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## 11.78 wo covariates
 ## 22.16

final_item_word2vec = lm(data = x,
                           zRTTarget_trim ~ 1 + word2veccosine+
```

```
                           mean_len_c+ mean_logf_c +
                                mean_ldtz_c + mean_conc_c)
 summary(final_item_word2vec)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ 1 + word2veccosine + mean_len_c +
##     mean_logf_c + mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.88965 -0.30838 -0.02965  0.27696  1.93866
##
## Coefficients:
##                 Estimate Std. Error t value Pr(>|t|)
## (Intercept)     0.201872   0.031244   6.461 2.96e-10 ***
## word2veccosine -1.310156   0.143311  -9.142  < 2e-16 ***
## mean_len_c      0.037293   0.017340   2.151   0.0321 *
## mean_logf_c    -0.007669   0.021039  -0.365   0.7156
## mean_ldtz_c     0.691833   0.159246   4.344 1.76e-05 ***
## mean_conc_c    -0.043282   0.027760  -1.559   0.1197
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4308 on 409 degrees of freedom
## Multiple R-squared:  0.2803, Adjusted R-squared:  0.2715
## F-statistic: 31.86 on 5 and 409 DF,  p-value: < 2.2e-16
```

```
  #r2 = 16.01
# 28.03
final_item_directed = lm(data = x,
                           zRTTarget_trim ~ directedcollapsed +
                         mean_len_c+ mean_logf_c +
                           mean_ldtz_c + mean_conc_c)
 summary(final_item_directed)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ directedcollapsed + mean_len_c +
##     mean_logf_c + mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.03398 -0.31544 -0.05097  0.27253  1.84744
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)        -0.032711   0.025267  -1.295 0.196188
## directedcollapsed1 -0.348029   0.074755  -4.656 4.39e-06 ***
## directedcollapsed2 -0.226584   0.051393  -4.409 1.33e-05 ***
## directedcollapsed3 -0.045316   0.046051  -0.984 0.325684
## directedcollapsed4  0.111024   0.040416   2.747 0.006282 **
## directedcollapsed5  0.196184   0.049340   3.976 8.29e-05 ***
## mean_len_c          0.044464   0.017743   2.506 0.012603 *
## mean_logf_c         0.007924   0.021622   0.366 0.714197
```

```
## mean_ldtz_c         0.588039   0.163526   3.596 0.000363 ***
## mean_conc_c        -0.040210   0.028540  -1.409 0.159625
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4391 on 405 degrees of freedom
## Multiple R-squared:  0.2598, Adjusted R-squared:  0.2434
## F-statistic:  15.8 on 9 and 405 DF,  p-value: < 2.2e-16
```

```
#25.98
 anova(final_item_unconditional, final_item_directed)
```

```
## Analysis of Variance Table
##
## Model 1: zRTTarget_trim ~ 1 + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c
## Model 2: zRTTarget_trim ~ directedcollapsed + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1    410 91.434
## 2    405 78.080  5    13.354 13.853 1.661e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
final_item_kenett = lm(data = x,
                           zRTTarget_trim ~ kenettfac +
                       mean_len_c+ mean_logf_c +
                             mean_ldtz_c + mean_conc_c)
summary(final_item_kenett)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ kenettfac + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -0.9990 -0.2971 -0.0473  0.2659  1.8868
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.007382   0.021431  -0.344 0.730681
## kenettfac1  -0.375455   0.048092  -7.807 5.05e-14 ***
## kenettfac2  -0.103957   0.049491  -2.101 0.036302 *
## kenettfac3   0.115869   0.049509   2.340 0.019751 *
## kenettfac4   0.075282   0.047397   1.588 0.112992
## kenettfac5   0.141634   0.048162   2.941 0.003461 **
## mean_len_c   0.061149   0.017999   3.397 0.000748 ***
## mean_logf_c  0.001118   0.021397   0.052 0.958364
## mean_ldtz_c  0.645997   0.162375   3.978 8.22e-05 ***
## mean_conc_c -0.041800   0.028446  -1.469 0.142488
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4361 on 405 degrees of freedom
```

```
## Multiple R-squared:  0.2699, Adjusted R-squared:  0.2537
## F-statistic: 16.64 on 9 and 405 DF,  p-value: < 2.2e-16
```

```
 #26.99

  anova(final_item_unconditional, final_item_kenett)
```

```
## Analysis of Variance Table
##
## Model 1: zRTTarget_trim ~ 1 + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c
## Model 2: zRTTarget_trim ~ kenettfac + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c
##   Res.Df    RSS Df Sum of Sq      F    Pr(>F)
## 1    410 91.434
## 2    405 77.017  5    14.417 15.163 1.156e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
  final_item_lsa = lm(data = x,
                              zRTTarget_trim ~ LSA +
                        mean_len_c+ mean_logf_c +
                                mean_ldtz_c + mean_conc_c)
 summary(final_item_lsa)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ LSA + mean_len_c + mean_logf_c +
##     mean_ldtz_c + mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.85976 -0.30721 -0.03932  0.26967  1.91099
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.1648187  0.0305897   5.388 1.21e-07 ***
## LSA         -1.1852921  0.1483330  -7.991 1.38e-14 ***
## mean_len_c   0.0447574  0.0177441   2.522 0.012035 *
## mean_logf_c -0.0001625  0.0214581  -0.008 0.993962
## mean_ldtz_c  0.5647336  0.1641773   3.440 0.000642 ***
## mean_conc_c -0.0608816  0.0282601  -2.154 0.031798 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4397 on 409 degrees of freedom
## Multiple R-squared:  0.2503, Adjusted R-squared:  0.2411
## F-statistic: 27.31 on 5 and 409 DF,  p-value: < 2.2e-16
```

```
 # 14.79
 # 25.05
 ## model with covariates

# > AIC(final_item_kenett)
# [1] 500.7552
# > AIC(final_item_undirected)
```

```
# [1] 523.3278
# > AIC(final_item_directed)
# [1] 506.4442
# > AIC(final_item_lsa)
# [1] 503.7628
# > AIC(final_item_word2vec)
# [1] 486.8023

 ## model without covariates

#  > AIC(final_item_undirected)
# [1] 567.2967
# > AIC(final_item_directed)
# [1] 546.206
# > AIC(final_item_kenett)
# [1] 563.0322
# > AIC(final_item_lsa)
# [1] 548.8717
# > AIC(final_item_word2vec)
# [1] 542.8845

 ## model with covariates

# > stats4::BIC(final_item_kenett)
# [1] 545.0662
# > stats4::BIC(final_item_undirected)
# [1] 559.5823
# > stats4::BIC(final_item_directed)
# [1] 550.7553
# > stats4::BIC(final_item_lsa)
# [1] 531.9608
# > stats4::BIC(final_item_word2vec)
# [1] 515.0003

 ## modelwithout covariates

#  > stats4::BIC(final_item_word2vec)
# [1] 554.9694
# > stats4::BIC(final_item_directed)
# [1] 574.404
# > stats4::BIC(final_item_undirected)
# [1] 587.4381
# > stats4::BIC(final_item_kenett)
# [1] 591.2302
# > stats4::BIC(final_item_lsa)
# [1] 560.9565

 final_item_multiple = lm(data = x,
                              zRTTarget_trim ~ directedcollapsed + kenettfac +
                            undirectedfac +
                            mean_len_c+ mean_logf_c +
                                mean_ldtz_c + mean_conc_c)
 summary(final_item_multiple)
```

```
##
## Call:
## lm(formula = zRTTarget_trim ~ directedcollapsed + kenettfac +
##     undirectedfac + mean_len_c + mean_logf_c + mean_ldtz_c +
##     mean_conc_c, data = x)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.89091 -0.29588 -0.04309  0.26430  1.81177
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)         0.006793   0.029805   0.228 0.819819
## directedcollapsed1 -0.123286   0.117075  -1.053 0.292957
## directedcollapsed2 -0.162015   0.058154  -2.786 0.005593 **
## directedcollapsed3 -0.101086   0.049738  -2.032 0.042781 *
## directedcollapsed4  0.046444   0.045124   1.029 0.303991
## directedcollapsed5  0.091187   0.055800   1.634 0.103017
## kenettfac1         -0.293635   0.062243  -4.718 3.31e-06 ***
## kenettfac2         -0.076544   0.051100  -1.498 0.134949
## kenettfac3          0.100972   0.048958   2.062 0.039820 *
## kenettfac4          0.083181   0.047568   1.749 0.081119 .
## kenettfac5          0.094390   0.052191   1.809 0.071275 .
## undirectedfac1     -0.029135   0.094044  -0.310 0.756876
## undirectedfac2      0.005971   0.046563   0.128 0.898035
## undirectedfac3     -0.027291   0.048763  -0.560 0.576017
## mean_len_c          0.058771   0.017663   3.327 0.000959 ***
## mean_logf_c         0.004122   0.021149   0.195 0.845565
## mean_ldtz_c         0.549854   0.161068   3.414 0.000707 ***
## mean_conc_c        -0.028795   0.028237  -1.020 0.308462
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.4265 on 397 degrees of freedom
## Multiple R-squared:  0.3156, Adjusted R-squared:  0.2862
## F-statistic: 10.77 on 17 and 397 DF,  p-value: < 2.2e-16
```

```
car::Anova(final_item_multiple)
```

```
## Anova Table (Type II tests)
##
## Response: zRTTarget_trim
##                    Sum Sq  Df F value    Pr(>F)
## directedcollapsed   4.099   5  4.5076 0.0005228 ***
## kenettfac           4.617   5  5.0779 0.0001590 ***
## undirectedfac       0.193   3  0.3543 0.7860444
## mean_len_c          2.013   1 11.0711 0.0009586 ***
## mean_logf_c         0.007   1  0.0380 0.8455647
## mean_ldtz_c         2.119   1 11.6541 0.0007066 ***
## mean_conc_c         0.189   1  1.0399 0.3084624
## Residuals          72.201 397
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Combined Plot

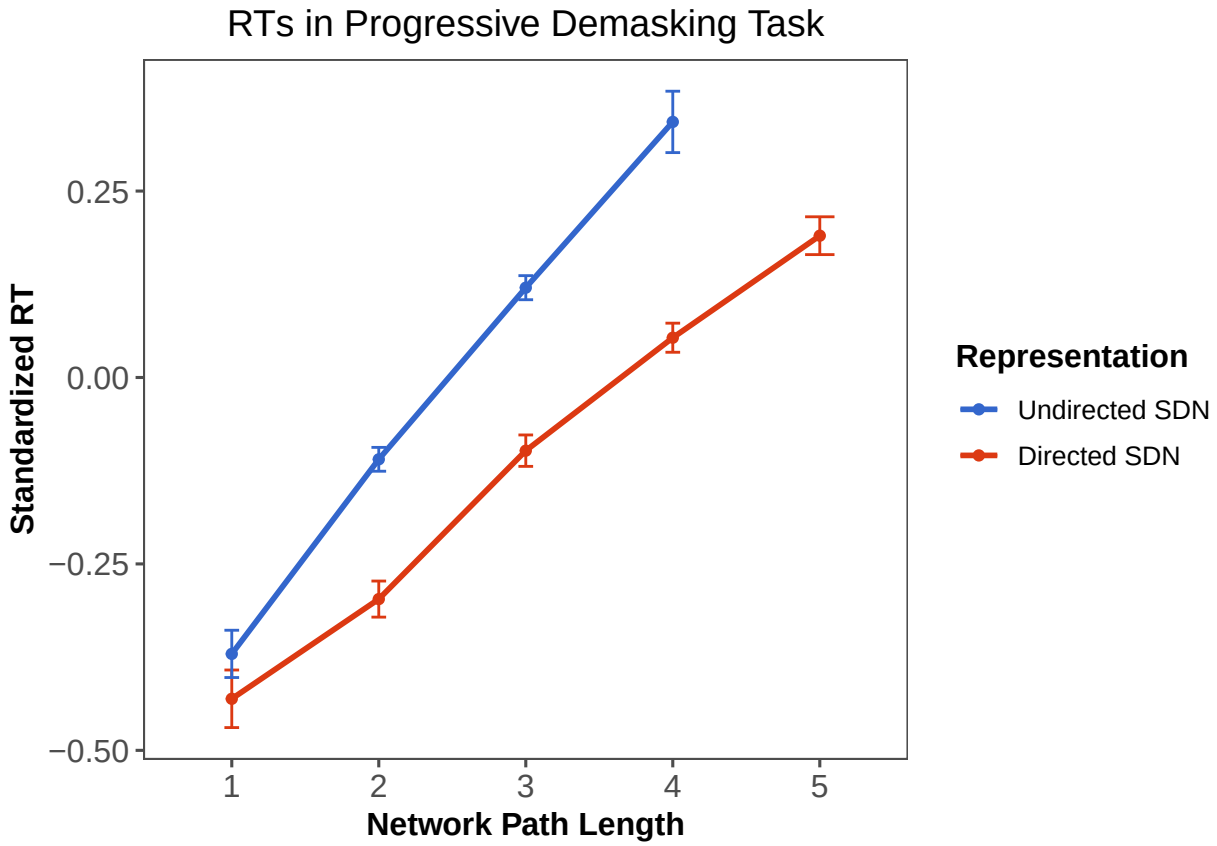
Reversing Cosines

```
final_word2vec$undirectedfacfinal = as.factor(final_word2vec$zUndirected)
final_word2vec$directedfacfinal = as.factor(final_word2vec$zDirected)
final_word2vec$kenettfacfinal = as.factor(final_word2vec$zKenett)
final_word2vec$LSAfacfinal = as.factor(round(final_word2vec$LSAquintile))
final_word2vec$word2vecfacfinal = as.factor(round(final_word2vec$word2vecquintile))

word2vec_cosine_agg  = Rmisc::summarySE(final_word2vec,
                                        measurevar = "zRTTarget_trim",
                                        groupvars = c("word2vecfacfinal"))

# original data in word2vec_cosine_agg
word2vec_cosine_agg = word2vec_cosine_agg[,-c(1)]
x = as.data.frame(matrix(NA, nrow = 5, ncol = 1))
colnames(x) = "pathlength"
x$pathlength = c(5,4,3,2,1)
word2vec_cosine_agg = cbind(x, word2vec_cosine_agg)
word2vec_cosine_agg$pathlengthfac = as.factor(word2vec_cosine_agg$pathlength)
word2vec_cosine_agg$Network = "word2vec"

lsa_cosine_agg  = Rmisc::summarySE(final_word2vec,
                                        measurevar = "zRTTarget_trim",
                                        groupvars = c("LSAfacfinal"))
lsa_cosine_agg = lsa_cosine_agg %>% filter(!is.na(lsa_cosine_agg$LSAfacfinal))
# original data in lsa_cosine_agg
lsa_cosine_agg = lsa_cosine_agg[,-c(1)]
x = as.data.frame(matrix(NA, nrow = 5, ncol = 1))
colnames(x) = "pathlength"
x$pathlength = c(5,4,3,2,1)
lsa_cosine_agg = cbind(x, lsa_cosine_agg)
lsa_cosine_agg$pathlengthfac = as.factor(lsa_cosine_agg$pathlength)
lsa_cosine_agg$Network = "LSA"
```

Final Plot

```
colnames(z_rmisc_directed_collapsed) = colnames(z_rmisc_kenett)
colnames(z_rmisc_undirected) = colnames(z_rmisc_kenett)
z_rmisc_directed_collapsed = z_rmisc_directed_collapsed %>%
  filter(!pathlengthfac == "H")

z_rmisc_combined = rbind(z_rmisc_kenett, z_rmisc_undirected,
                         z_rmisc_directed_collapsed,
                         word2vec_cosine_agg,
                         lsa_cosine_agg)


z_rmisc_combined$Network = as.factor(z_rmisc_combined$Network)
```

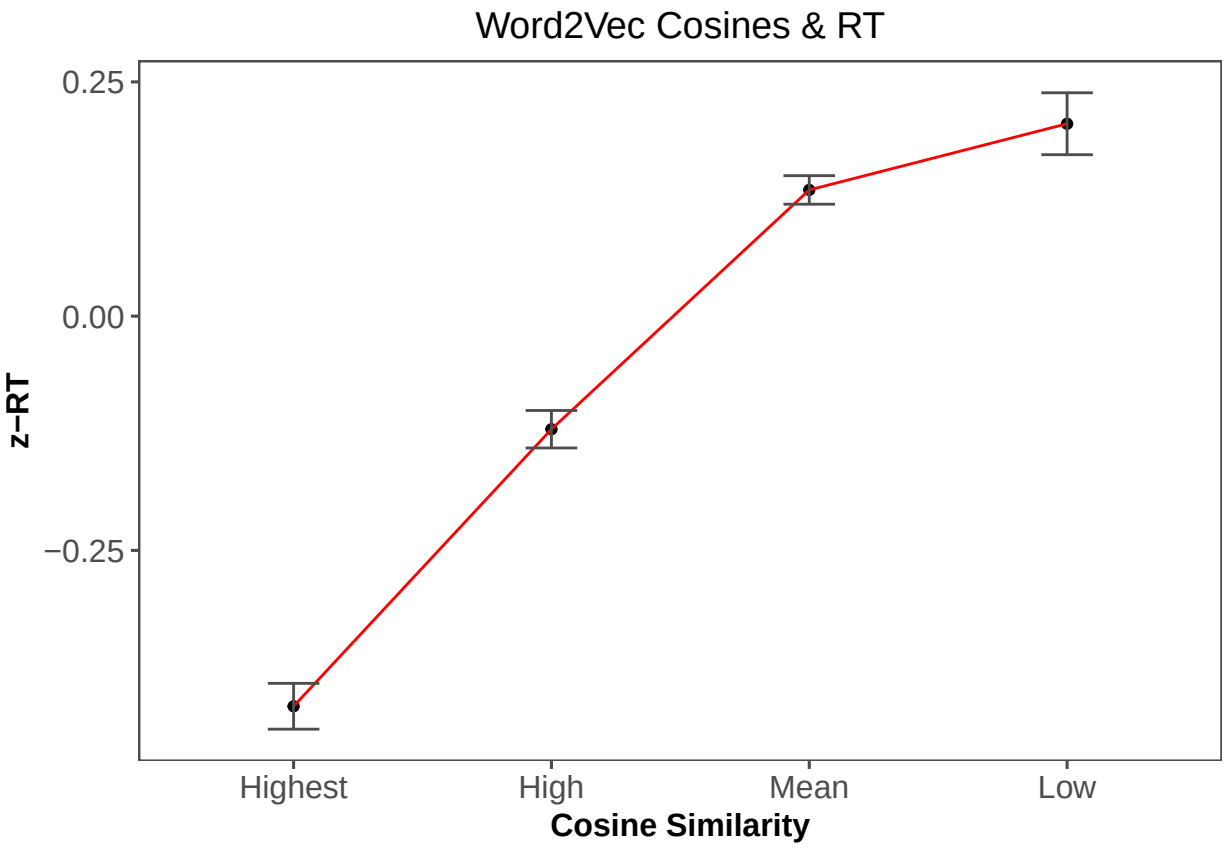
```
z_rmisc_combined$pathlengthfac = ordered(as.factor(as.character(z_rmisc_combined$pathlength)),
                              levels = c("1", "2", "3", "4", "5", "6","15"))

colnames(z_rmisc_combined) = c("pathlength", "N", "zRTTarget_trim",
                                 "sd", "se", "ci", "pathlengthfac", "Model")

z_rmisc_combined$Representation = c("ACN", "ACN", "ACN", "ACN", "ACN", "ACN",
                                    "Undirected SDN", "Undirected SDN",
                                    "Undirected SDN","Undirected SDN",
                                    "Directed SDN","Directed SDN",
                                    "Directed SDN","Directed SDN",
                                    "Directed SDN",
                                    "word2vec","word2vec","word2vec",
                                    "word2vec","word2vec",
                                    "LSA","LSA","LSA","LSA","LSA")
z_rmisc_combined$Representation=
  ordered(as.factor(as.character(z_rmisc_combined$Representation)),
    levels = c("ACN", "Undirected SDN", "Directed SDN", "LSA", "word2vec"))

library(ggplot2)
library(ggthemes)

z_rmisc_combined1 =z_rmisc_combined %>%
  filter(! Representation %in% c("ACN", "LSA", "word2vec"))

z_rmisc_combined1 %>%
  ggplot(aes(x = pathlengthfac, y = zRTTarget_trim,
             group = Representation, color = Representation))+
  geom_point()+
#  geom_smooth(method = "loess")+
geom_line(size = 1)+
    geom_errorbar(aes(ymin=zRTTarget_trim - se, ymax=zRTTarget_trim + se),
                width=.2,
                position = position_dodge(0))+
 theme_few()+
  scale_color_gdocs()+
  #scale_x_continuous(breaks = c(1,2,3,4,5,6,10,15,20))+
    xlab("Network Path Length") + ylab("Standardized RT") +
  ggtitle("RTs in Progressive Demasking Task")  +
   theme(axis.text = element_text(size = rel(1)),
          axis.title = element_text(face = "bold", size = rel(1)),
          legend.title = element_text(face = "bold", size = rel(1)),
         plot.title = element_text(hjust = .5),
         strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



RTs and Word2Vec

```
meanCosine = mean(final_word2vec$word2veccosine)
sdCosine = sd(final_word2vec$word2veccosine)
lowest = meanCosine - 2*sdCosine
low = meanCosine - sdCosine
high = meanCosine + sdCosine
highest = meanCosine + 2*sdCosine

final_word2vec$cosinefac =  ifelse(final_word2vec$word2veccosine <= lowest, "Lowest", ifelse(final_word
                ifelse(final_word2vec$word2veccosine <= meanCosine, "Mean",
         ifelse(final_word2vec$word2veccosine <= high, "High", "Highest"))))

final_word2vec$cosinefac2 = ordered(as.factor(as.character(final_word2vec$cosinefac)),
      levels = c("Highest", "High", "Mean", "Low", "Lowest"))

word2vec_cosine_agg  = Rmisc::summarySE(final_word2vec,
                                        measurevar = "zRTTarget_trim",
                                        groupvars = c("cosinefac2"))
ggplot(word2vec_cosine_agg,
       aes(x = cosinefac2, y = zRTTarget_trim))+
geom_point()+
geom_line(group = 1, color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - se, ymax=zRTTarget_trim + se),
              width=.2, color = "gray30",
```

```
            position = position_dodge(0.05))+
  theme_few()+
    xlab("Cosine Similarity") + ylab("z-RT") +
  ggtitle("Word2Vec Cosines & RT")  +
   theme(axis.text = element_text(size = rel(1)),
          axis.title = element_text(face = "bold", size = rel(1)),
          legend.title = element_text(face = "bold", size = rel(1)),
         plot.title = element_text(hjust = .5),
         strip.text.x = element_text(face = "bold", size = rel(1.4)))
```



word2vec Quintile

```
final_word2vec = final_word2vec %>%
    mutate(quantile = ntile(word2veccosine, 5))

word2vec_cosine_agg  = Rmisc::summarySE(final_word2vec,
                                        measurevar = "zRTTarget_trim",
                                        groupvars = c("quantile"))
ggplot(word2vec_cosine_agg,
       aes(x = -quantile, y = zRTTarget_trim))+
geom_point()+
geom_line(group = 1, color = "red")+
   geom_errorbar(aes(ymin=zRTTarget_trim - se, ymax=zRTTarget_trim + se),
              width=.2, color = "gray30",
              position = position_dodge(0.05))+
  theme_few()+
```

```
  xlab("Cosine Similarity") + ylab("z-RT") +
ggtitle("Word2Vec Cosines & RT")  +
 theme(axis.text = element_text(size = rel(1)),
        axis.title = element_text(face = "bold", size = rel(1)),
        legend.title = element_text(face = "bold", size = rel(1)),
       plot.title = element_text(hjust = .5),
       strip.text.x = element_text(face = "bold", size = rel(1.4)))
```