

multiple_possibilities_GLMM

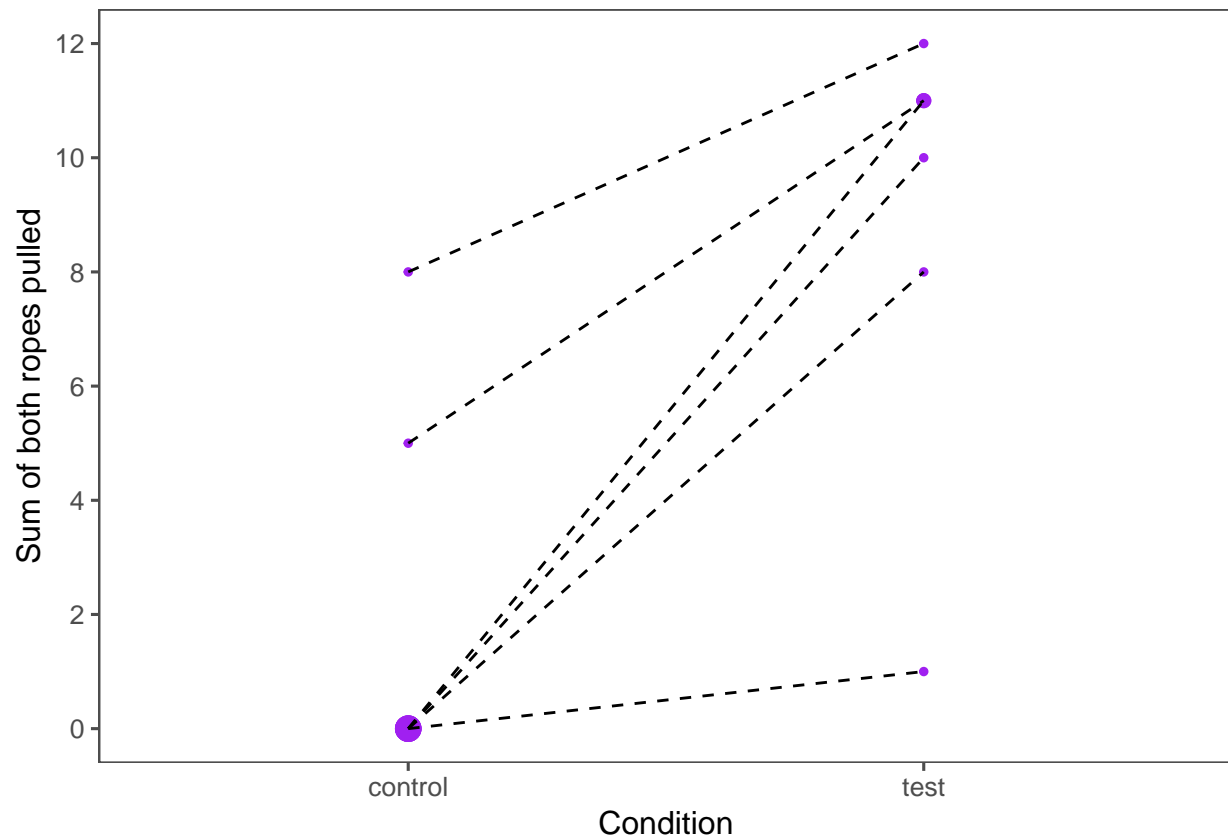
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April 04, 2019

Summary

Both the paired-samples t-test and a mixed model show a significant effect for condition. There was no significant interaction between session and condition.

Plotting data



Paired-sample t-test

```
contr_data <- plot_individual %>%
  filter(condition == "control")

exp_data <- plot_individual %>%
  filter(condition == "test")

t.test(exp_data$correct_resp, contr_data$correct_resp, paired = TRUE, alternative = "two.sided")

##
## Paired t-test
##
## data: exp_data$correct_resp and contr_data$correct_resp
## t = 4.3234, df = 5, p-value = 0.007546
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
##  2.702818 10.630515
## sample estimates:
## mean of the differences
##                6.666667
```

GLMM

GLMM 01 with session * condition interaction

```
# centering variables for modeling
model.data <- all.data %>%
  mutate(z.trial = scale(trial, scale = T, center = T),
         z.session = scale(session, scale=T, center=T),
         condition = relevel(condition, ref = "control"))

## code to run the model
mm.1 <- glmer(both_ropes ~ condition*z.session + z.trial +
              (1+ z.session|chimp)
              , data = model.data
              , family = binomial
              , control=glmerControl(optimizer="bobyqa",optCtrl=list(maxfun=2e5))
              )
```

Confidence intervals

Confidence intervals for the binomial models were derived using the function bootMer of the R package lme4, using 1,000 parametric bootstraps and bootstrapping over the random effects.

```
boot.res=boot.glmm(model.res=mm.1, excl.warnings=T,nboots=1000, para=F)
saveRDS(boot.res, "multpos_model.rds")
```

```
##
## orig X2.5. X97.5.
## (Intercept) -2.728 -9.061 -0.435
## conditiontest 4.443 3.195 9.990
## z.session 0.528 -0.444 5.131
## z.trial 0.630 0.041 1.534
## conditiontest:z.session -0.528 -5.462 0.929
```

Null model

```
mm.1.null <- glmer(both_ropes ~ 1 +  
  (1+z.session|chimp)  
  , data = model.data  
  , family = binomial  
  , control=glmerControl(optimizer="bobyqa",optCtrl=list(maxfun=2e5))  
)
```

```
## singular fit
```

Full-null model comparison

```
anova(mm.1, mm.1.null, test="Chisq")
```

```
## Data: model.data  
## Models:  
## mm.1.null: both_ropes ~ 1 + (1 + z.session | chimp)  
## mm.1: both_ropes ~ condition * z.session + z.trial + (1 + z.session |  
## mm.1:      chimp)  
##           Df      AIC      BIC logLik deviance Chisq Chi Df Pr(>Chisq)  
## mm.1.null  4 183.37 195.25 -87.686 175.373  
## mm.1       8 111.67 135.43 -47.833  95.667 79.706      4 < 2.2e-16 ***  
## ---  
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model output

- Coefficients

```
round(summary(mm.1)$coefficients, 3)
```

```
##           Estimate Std. Error z value Pr(>|z|)  
## (Intercept)      -3.901      1.827  -2.135   0.033  
## conditiontest       6.366      1.945   3.272   0.001  
## z.session          1.608      1.291   1.246   0.213  
## z.trial            0.714      0.312   2.288   0.022  
## conditiontest:z.session -2.368      1.853  -1.278   0.201
```

- Individual predictors: likelihood ratio tests

Drop1: P values for the individual effects were based on likelihood ratio tests comparing the full with respective reduced models (Barr et al., 2013; R function drop1 with argument 'test' set to "Chisq").

```
xdrop1=drop1(mm.1, test="Chisq")
```

```
## singular fit  
## singular fit
```

```
round(xdrop1,3)
```

```
## Single term deletions  
##  
## Model:  
## both_ropes ~ condition * z.session + z.trial + (1 + z.session |  
##      chimp)  
##           Df      AIC      LRT Pr(Chi)  
## <none>          111.67  
## z.trial         1 115.65 5.981  0.014 *
```

```
## condition:z.session 1 113.25 3.580 0.058 .
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

GLMM02 without the interaction

```
mm.2 <- glmer(both_ropes ~ condition+z.session + z.trial +
              (1|chimp)
              , data = model.data
              , family = binomial
              , control=glmerControl(optimizer="bobyqa",optCtrl=list(maxfun=2e5))
              )
```

Confidence intervals

Confidence intervals for the binomial models were derived using the function bootMer of the R package lme4, using 1,000 parametric bootstraps and bootstrapping over the random effects.

```
boot.res2=boot.glmm(model.res=mm.2, excl.warnings=T,nboots=1000, para=F)
saveRDS(boot.res2, "multpos_model2.rds")
```

```
##           orig  X2.5. X97.5.
## (Intercept) -2.688 -6.605 -0.204
## conditiontest 4.389  2.969  7.883
## z.session     0.256 -0.335  0.950
## z.trial       0.622  0.063  1.438
```

Null model

```
mm.2.null <- glmer(both_ropes ~ 1 +
                  (1|chimp)
                  , data = model.data
                  , family = binomial
                  , control=glmerControl(optimizer="bobyqa",optCtrl=list(maxfun=2e5))
                  )
```

Full-null model comparison

```
anova(mm.2, mm.2.null, test="Chisq")
```

```
## Data: model.data
## Models:
## mm.2.null: both_ropes ~ 1 + (1 | chimp)
## mm.2: both_ropes ~ condition + z.session + z.trial + (1 | chimp)
##           Df      AIC      BIC logLik deviance Chisq Chi Df Pr(>Chisq)
## mm.2.null  2 179.38 185.32 -87.691  175.382
## mm.2       5 109.25 124.10 -49.626   99.253  76.129     3 < 2.2e-16 ***
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Model output

- Coefficients

```
round(summary(mm.2)$coefficients, 3)
```

```
##           Estimate Std. Error z value Pr(>|z|)
## (Intercept)   -3.069     1.248  -2.460   0.014
## conditiontest    5.095     0.980   5.198   0.000
## z.session       0.156     0.281   0.555   0.579
## z.trial         0.681     0.300   2.268   0.023
```

- Individual predictors: likelihood ratio tests

Drop1: P values for the individual effects were based on likelihood ratio tests comparing the full with respective reduced models (Barr et al., 2013; R function drop1 with argument 'test' set to "Chisq").

```
xdrop1=drop1(mm.2, test="Chisq")
round(xdrop1,3)
```

```
## Single term deletions
##
## Model:
## both_ropes ~ condition + z.session + z.trial + (1 | chimp)
##           Df      AIC      LRT Pr(Chi)
## <none>         109.25
## condition  1 180.44 73.184  <2e-16 ***
## z.session  1 107.56  0.310   0.578
## z.trial    1 113.00  5.743   0.017 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

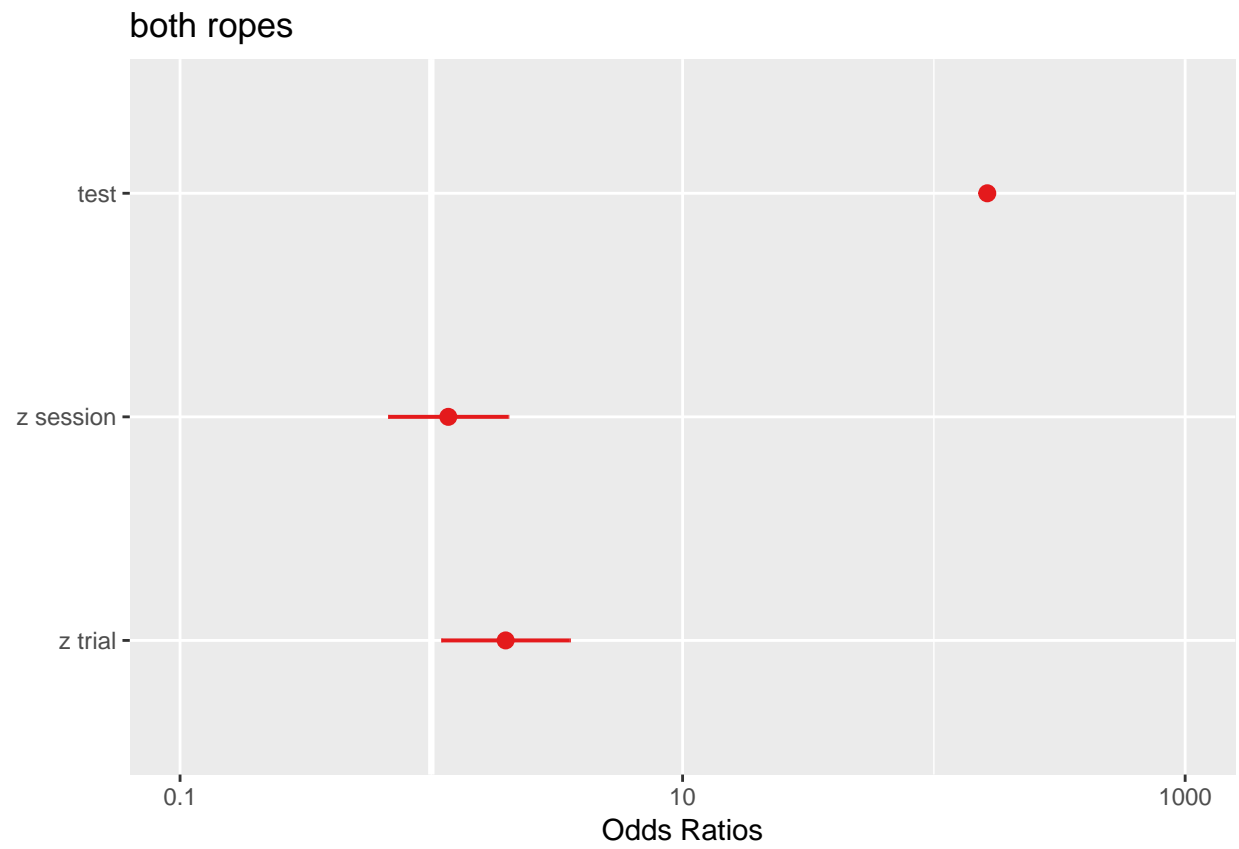
check for colinearity in the previous model.

```
## condition  z.trial z.session
## 1.042645  1.040646  1.002028
```

-> no collinearity

Model output

```
plot_model(mm.2, type='est')
```



```
plot_model(mm.2, type='re')
```

Random effects

