Mean_Error_Dot_Plot

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```
# Libraries used
library(lme4)
```

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

```
# library(lmerTest) # we use this below but it conflicts with lme4's lmer function
library(effects)
```

```
## Loading required package: carData
```

```
## lattice theme set by effectsTheme()
## See ?effectsTheme for details.
```

```
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
# Load in data
setwd("~/Desktop")
setwd("~/Dropbox/ARGHCodingClub/Mean_Error_Dot_Plot")
d<-read.csv("RivulusMirrorET.csv")

# File containing the Emersion Threshold Data from fish heated in the
# presence of a mirror under-water
# Hypothesis: Reflection and social behaviours interfere with decision to leave water
# under thermal stress
str(d)
```

```
## 'data.frame':    30 obs. of  24 variables:
##  $ FishID      : Factor w/ 15 levels "C1-1-19","T1",..: 1 2 8 9 10 11 12 1 2 8 ...
##  $ Length.mm   : int  14 28 28 25 29 23 23 14 28 28 ...
##  $ Mass.g      : num  0.022 0.28 0.295 0.225 0.344 0.162 0.175 0.022 0.28 0.295 ...
##  $ Locale      : Factor w/ 2 levels "Croc1","Tarpin": 1 2 2 2 2 2 2 1 2 2 ...
##  $ Date        : Factor w/ 2 levels "22-Apr","23-Apr": 1 1 1 1 1 1 1 1 1 1 ...
##  $ Treatment   : Factor w/ 2 levels "Mirror","Opaque": 1 1 1 1 1 2 2 2 2 2 ...
##  $ Order       : int  1 1 1 1 1 1 1 2 2 2 ...
##  $ RateHeat    : num  1 0.8 0.882 0.9 1 ...
##  $ ExptDuration: int  11 10 11 11 9 9 11 9 11 11 ...
##  $ SENum       : int  2 13 24 12 7 22 38 26 24 23 ...
##  $ BSNum       : int  0 6 6 4 3 9 13 7 2 5 ...
##  $ ENum        : int  1 1 1 1 1 2 2 1 1 1 ...
```

```
##  $ LDNum       : int  6 16 21 17 29 0 0 0 0 0 ...
##  $ MCNum       : int  10 1 0 2 7 0 0 0 0 0 ...
##  $ SET1        : num  42.7 39.6 37.5 37.5 38.3 31.8 32.1 32.2 33.5 31.7 ...
##  $ BST1        : num  NA 40.5 38.4 38.5 38.5 34.6 34.1 35.1 38 38 ...
##  $ ET1         : num  43.3 42 40.8 40.4 40.4 39.3 39.8 38.6 41.5 39.8 ...
##  $ LDT1        : num  32.9 32.2 31.5 31.2 30.5 NA NA NA NA NA ...
##  $ MCT1        : num  32.5 34.5 NA 35.2 31.1 NA NA NA NA NA ...
##  $ SETMed      : num  43 41 38.9 39 39.7 ...
##  $ BSTMed      : num  NA 41.2 39.7 39.6 39.1 ...
##  $ ETMed       : num  43.3 42 40.8 40.4 40.4 ...
##  $ LDTMed      : num  38.2 37.4 34.7 32.8 32.6 ...
##  $ MCTMed      : num  36.6 34.5 NA 35.9 36.1 ...
```

```
# Factorise
d$Order<-factor(d$Order)
d$Treatment<-relevel(d$Treatment, ref="Opaque")


# Calculate rates of behaviours per min
d$SENum<-d$SENum/d$ExptDuration
d$BSNum<-d$BSNum/d$ExptDuration
d$LDNum<-d$LDNum/d$ExptDuration
d$MCNum<-d$MCNum/d$ExptDuration
d$SurfaceScore<-d$SENum+d$BSNum
d$MirrorScore<-d$MCNum+d$LDNum
# SE = Surface Excursion
# BS = Break Surface
# LD = Lateral Display (toward Mirror)
# MC = Mirror Charge
# Normalise the counts to the duration of the experiment

# Note: We only really need the Treatment and ET1 columns for this exercise

# Create two functions to allow 95% CI to be calculated
lower<-function(x){
  xbar<-mean(x)
  se<-sd(x)/sqrt(length(x))
  lwr<-xbar-1.96*se
  return(lwr)
}

upper<-function(x){
  xbar<-mean(x)
  se<-sd(x)/sqrt(length(x))
  lwr<-xbar+1.96*se
  return(lwr)
}

# summarise data using dplyr piping (%>%)
ds<-d[c("Treatment", "ET1")] %>%
  group_by(Treatment) %>%
  summarise_all(funs(mean, lower, upper))
ds
```

```
## # A tibble: 2 x 4
```

```
##   Treatment  mean lower upper
##   <fct>     <dbl> <dbl> <dbl>
## 1 Opaque     40.5  39.9  41.1
## 2 Mirror     41.8  41.3  42.2
```

```
# Model Fits ####
lmET1<-lmer(ET1 ~ Treatment + Order + (1|FishID), data=d)
```

```
## singular fit
```

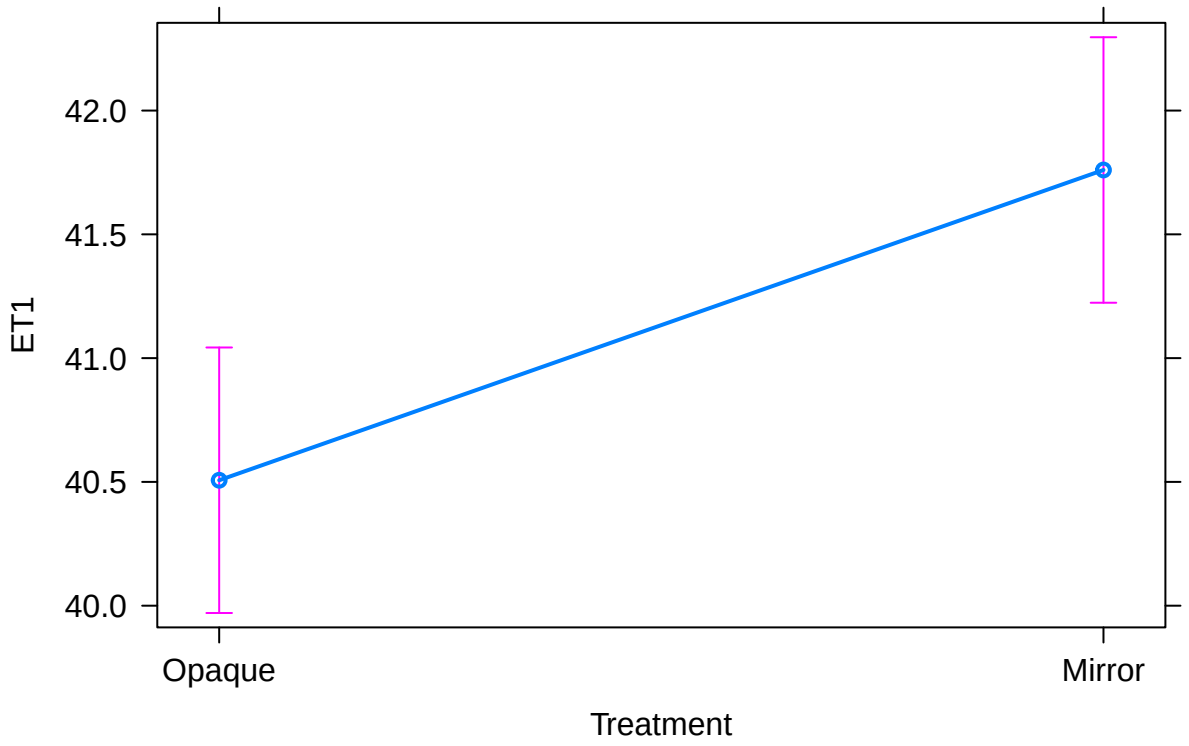
```
# Explicitly call lmerTest's lmer function:
lmET1<-lmerTest::lmer(ET1 ~ Treatment  + (1|FishID), data=d)
summary(lmET1)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: ET1 ~ Treatment + (1 | FishID)
##    Data: d
##
## REML criterion at convergence: 85.6
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.0175 -0.6716  0.2548  0.6635  1.5482
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  FishID   (Intercept) 0.02671  0.1634
##  Residual             1.00133  1.0007
## Number of obs: 30, groups:  FishID, 15
##
## Fixed effects:
##                 Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)      40.5067     0.2618 27.9811  154.73  < 2e-16 ***
## TreatmentMirror   1.2533     0.3654 14.0000    3.43  0.00406 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## TretmntMrrr -0.698
```

```
anova(lmET1, ddf="Satterthwaite")
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value   Pr(>F)
## Treatment 11.781  11.781     1    14  11.766 0.004062 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Model effects (i.e. the predicted values + 95% CI)
effET1<-Effect("Treatment", lmET1)
plot(effET1)
```




```
# put model effects into a data.frame for ggplotting
effET1<-data.frame(Effect("Treatment", lmET1), P=c("P = 0.0041", NA))
str(effET1)
```

```
## 'data.frame':    2 obs. of  6 variables:
##  $ Treatment: Factor w/ 3 levels "Mirror","Opaque",..: 2 1
##  $ fit      : num  40.5 41.8
##  $ se       : num  0.262 0.262
##  $ lower    : num  40 41.2
##  $ upper    : num  41 42.3
##  $ P        : Factor w/ 1 level "P = 0.0041": 1 NA
```

```
effET1
```

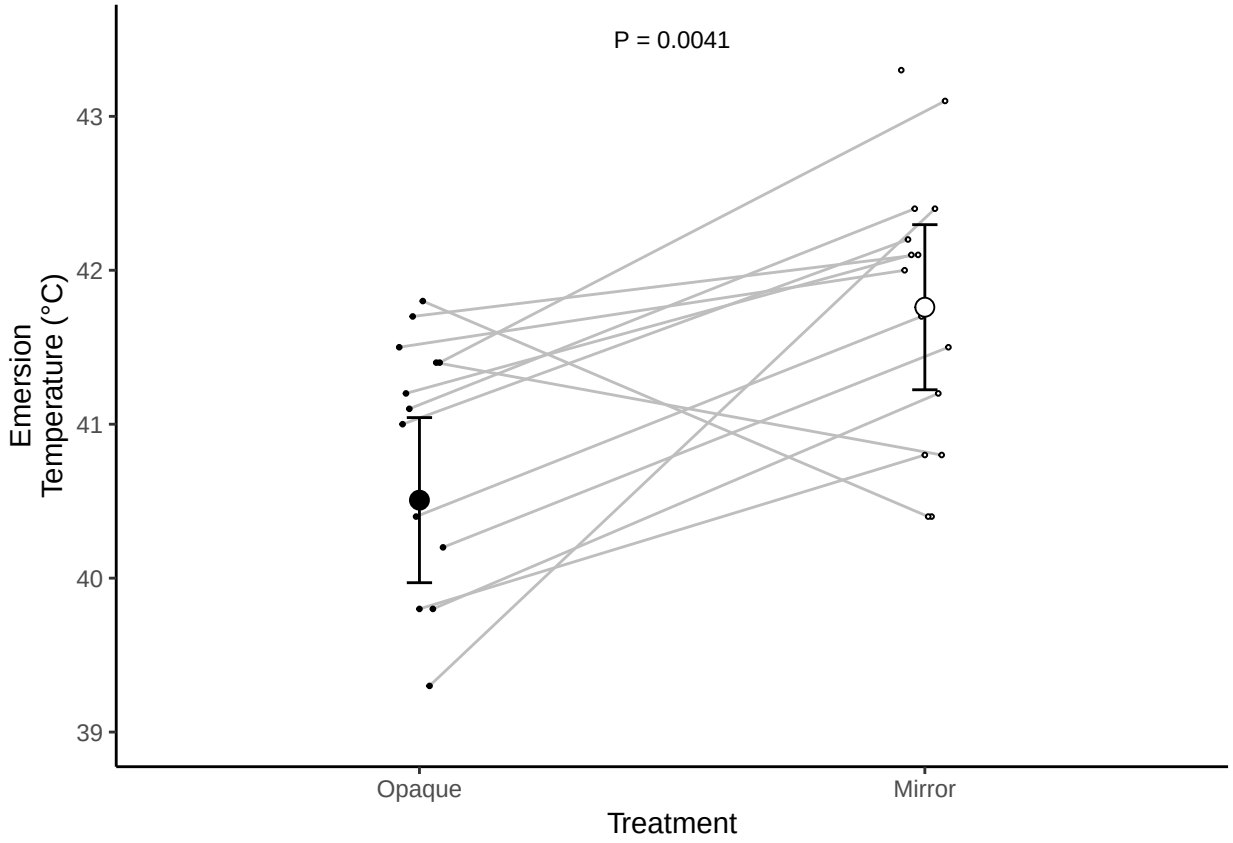
```
##   Treatment      fit        se    lower    upper          P
## 1    Opaque 40.50667 0.2617948 39.97040 41.04293 P = 0.0041
## 2    Mirror 41.76000 0.2617948 41.22374 42.29626       <NA>
```

```
# Emersion Threshold Figure ####
dodge<-position_dodge(width=.1)
ET1.plot<-ggplot()+
  geom_line(data=d, aes(x=Treatment, y=ET1, group=FishID), col="grey", position=dodge)+
  geom_point(data=d, aes(x=Treatment, y=ET1, fill=Treatment, group=FishID), shape=21, position=dodge, si
  geom_errorbar(data=effET1, aes(x=Treatment, ymin=lower, ymax=upper), width=0.05, size=0.5)+
  geom_point(data=effET1, aes(x=Treatment, y=fit, fill=Treatment), col="black", shape=21, size=3)+
  annotate("label", x=1.5, y=43.5, label = effET1$P[1], size=3, label.size=NA)+
  scale_fill_manual(values=c("black", "white"), name="", guide=F)+
  ylab("Emersion\nTemperature (°C)")+
  xlab("Treatment")+
```

```
  ylim(39,43.5)+
  theme_classic()+
  #  ggtheme(10,0.3)+
  theme(legend.position=c(0.15,0.85))+
  theme(panel.border = element_rect(fill=NA, colour=NA))
ET1.plot
```

```
## Warning: Removed 2 rows containing missing values (geom_path).
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```




```
# ggsave("Figure 1 - Mirror vs Opaque Emersion Thresholds.pdf", ET1.plot,  width=4, height=4)


lmSE<-lmer(SurfaceScore ~ Treatment + (1|FishID), d)
lmSE<-lmerTest::lmer(SurfaceScore ~ Treatment + (1|FishID), d)
summary(lmSE)
```

```
## Linear mixed model fit by REML. t-tests use Satterthwaite's method [
## lmerModLmerTest]
## Formula: SurfaceScore ~ Treatment + (1 | FishID)
##    Data: d
##
## REML criterion at convergence: 109.5
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -1.0965 -0.4339 -0.1476  0.2599  3.4177
```

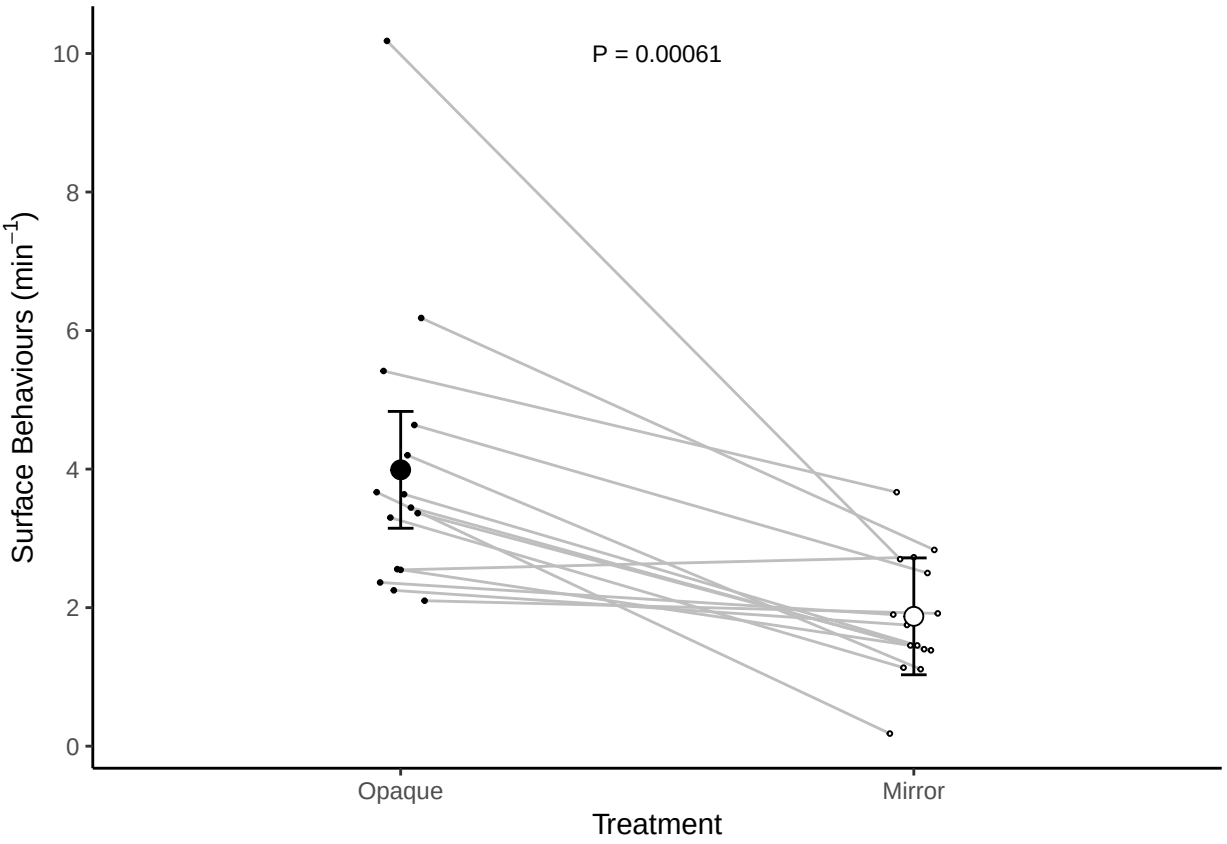
```
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  FishID   (Intercept) 0.8038   0.8965
##  Residual             1.7387   1.3186
## Number of obs: 30, groups:  FishID, 15
##
## Fixed effects:
##                 Estimate Std. Error      df t value Pr(>|t|)
## (Intercept)       3.9895     0.4117 25.4559   9.690 5.03e-10 ***
## TreatmentMirror  -2.1152     0.4815 14.0000  -4.393 0.000613 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Correlation of Fixed Effects:
##             (Intr)
## TretmntMrrr -0.585
```

```
anova(lmSE, ddf="Satterthwaite")
```

```
## Type III Analysis of Variance Table with Satterthwaite's method
##           Sum Sq Mean Sq NumDF DenDF F value    Pr(>F)
## Treatment 33.557  33.557     1    14    19.3 0.0006128 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
effSE<-data.frame(Effect("Treatment", lmSE), P=c("P = 0.00061", NA))

SE_emersion.plot<-ggplot()+
  geom_line(data=d, aes(x=Treatment, y=SurfaceScore, group=FishID), col="grey", position=dodge)+
  geom_point(data=d, aes(x=Treatment, y=SurfaceScore, fill=Treatment, group=FishID), shape=21, position=
  geom_errorbar(data=effSE, aes(x=Treatment, ymin=lower, ymax=upper), width=0.05, size=0.5)+
  geom_point(data=effSE, aes(x=Treatment, y=fit, fill=Treatment), col="black", shape=21, size=3)+
  annotate("label", x=1.5, y=10, label = effSE$P[1], size=3, label.size=NA)+
  scale_fill_manual(values=c("black", "white"), name="", guide=F)+
  scale_y_continuous(breaks=c(0,2,4,6,8,10))+
  ylab(expression("Surface Behaviours (min"^-1*")", adj=0.5))+
  xlab("Treatment")+
  #  ggtheme(10,0.3)+
  theme_classic()+
  theme(legend.position=c(0.15,0.85))+
  theme(panel.border = element_rect(fill=NA, colour=NA))
SE_emersion.plot
```




```
library(cowplot)
```

```
##
## Attaching package: 'cowplot'
```

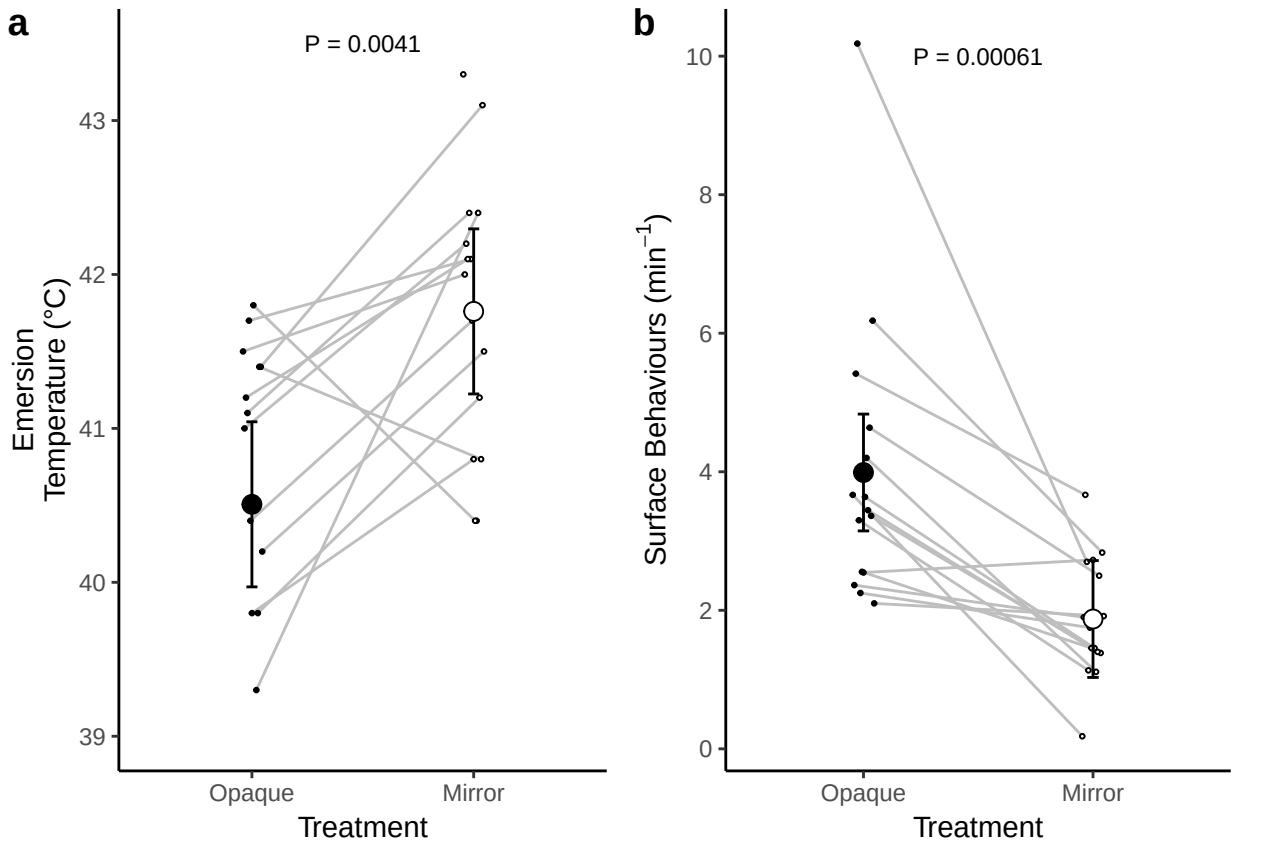
```
## The following object is masked from 'package:ggplot2':
##
##     ggsave
```

```
biplot<-plot_grid(ET1.plot, SE_emersion.plot, labels="auto")
```

```
## Warning: Removed 2 rows containing missing values (geom_path).
```

```
## Warning: Removed 2 rows containing missing values (geom_point).
```

```
biplot
```




```
# ggsave("Figure 2.pdf", biplot, width=8, height=4)
```