Circular Data Analysis and Visualizations with R

Sites of Circadian Clock Neuron Plasticity Mediate Sensory Integration and Entrainment

2/14/2020

Abstract

The data analysis and visualizations in this report have been developed for the paper *Sites of Circadian Clock Neuron Plasticity Mediate Sensory Integration and Entrainment*, authored by: Fernández MP[1], Pettibone HL, Roell CJ, Davey C, Huynh KV, Lennox S, Kostadinov B and Shafer OT[1].

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Introduction

We use R and RStudio for all data analysis and visualizations. The phase data are available in the paper cited above, and for the purpose of this data analysis we recorded it in the file `phases.csv`. The source R Markdown document (with `Rmd` extension) containing all R code is also available in the GitHub repository.

The key R package that we use for all circular data analysis and visualizations is **circular**. All R packages must be installed first before they are loaded with `library()`.

```
# load the R packages
library(readr) # for reading data
library(circular) # main computing package
library(scales) # for plot colors support
# load the phase data, which is available in the cited paper
phases <- read_csv("phases.csv")
```

```
# take phases modulo 24 to remove negative phases and convert to radians
radphases <- (phases %% 24)*pi/12 # hours in 00:24 and then radians in 0:2pi
cirradphases <- circular(radphases, units = "radians", template = "clock24",
                         modulo="2pi", zero=pi/2) # or zero=2*pi
```

Plot 1: PdfGal4, uasUNC5 and pdf>UNC5

In Figure 1, we show the raw circular data plots and rose diagrams of **PdfGal4**, **uasUNC5** and **pdf>UNC5**, based on the angles in radians, obtained from the phases.

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```r
# Plot 1
par(mar=c(rep(1,4))) # set up plot margins
# plot the circular data as a histogram with stack= TRUE
plot(cirradphases[,1], stack = TRUE, pch = 21, bg = alpha("gray77",0.8), col="darkgray",
     cex=0.8, sep = 0.08, shrink = 2.2,main="PdfGal4, uasUNC5 and pdf>UNC5",
     cex.main=0.8) # plot PdfGal4 [,1]

# calculate the circular means and point to them by arrows
circ.mean1<-mean(cirradphases[,1],na.rm = TRUE)
circ.mean2<-mean(cirradphases[,2],na.rm = TRUE)
circ.mean3<-mean(cirradphases[,3],na.rm = TRUE)

# adding points for uasUNC5 [,2] and pdf>UNC5 [,3]
points(cirradphases[,2],stack = TRUE, pch = 21, bg = alpha("gray60",0.8),
       col = "darkgray", cex=0.8, sep=0.08)
points(cirradphases[,3],stack=TRUE, pch = 21, bg = alpha("firebrick",0.8),
       col = "firebrick", cex=0.8, sep=0.08)

# adding arrows to circular means
arrows.circular(circ.mean1, col = alpha("gray77",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean2, col = alpha("gray60",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean3, col = alpha("firebrick",0.6), lwd=3) # arrow to circ. mean
legend(-0.3,-0.2,legend=c("Pdf-Gal4", "uas-UNC5","Pdf>UNC5"),
       col=c(alpha("gray77",0.9), alpha("gray60",0.8),alpha("firebrick",0.8)),
       pch=16,cex=0.8,box.lty=0)

# Rose diagrams
rose.diag(cirradphases[,1],bins=12,col=alpha("gray77",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,2],bins=12,col=alpha("gray60",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,3],bins=12,col=alpha("firebrick",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
```

Plot 2: Pdf-Gal4, uas-DBTL and Pdf>DBTL

In Figure 2, we show the raw circular data plots and rose diagrams of **Pdf-Gal4**, **uas-DBTL** and **Pdf>DBTL**, based on the angles in radians, obtained from the phases.

```r
# Plot 2
par(mar=c(rep(1,4))) # set plot margins
# plot the circular data for Pdf-Gal4 [1] as a histogram with stack = TRUE
plot(cirradphases[,1], stack = TRUE, pch = 21, bg = alpha("gray77",0.8), col="darkgray",
     cex=0.8, sep = 0.08, shrink = 2.2,
     main="Pdf-Gal4, uas-DBTL and Pdf>DBTL",
     cex.main=0.8) # plot PdfGal4 [,1]

# calculate the circular means and point to them by arrows
circ.mean1<-mean(cirradphases[,1],na.rm = TRUE) # Pdf-Gal4 [1]
circ.mean4<-mean(cirradphases[,4],na.rm = TRUE) # uas-DBTL [4]
circ.mean6<-mean(cirradphases[,6],na.rm = TRUE) # Pdf>DBTL [6]
```

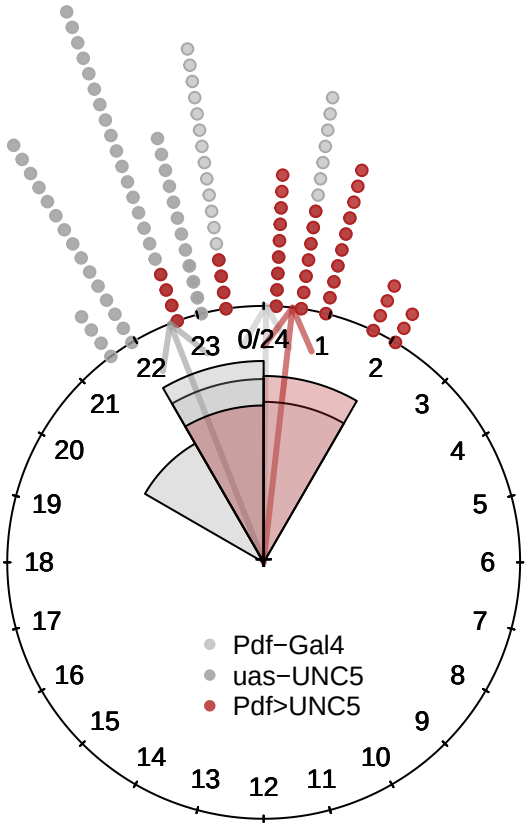

Figure 1: Circular plots and rose diagrams of PdfGal4, uasUNC5 and pdf>UNC5.

```
# adding points for uas-DBTL [4] and pdf>DBTL [6]
points(cirradphases[,4],stack = TRUE, pch = 21, bg = alpha("gray45",0.8),
       col = "darkgray", cex=0.8, sep=0.08)
points(cirradphases[,6],stack=TRUE, pch = 21, bg = alpha("gold3",0.8), col = "gold3",
       cex=0.8, sep=0.08)

# adding arrows to circular means
arrows.circular(circ.mean1, col = alpha("gray77",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean4, col = alpha("gray45",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean6, col = alpha("gold3",0.6), lwd=3) # arrow to circ. mean
legend(-0.3,-0.2,legend=c("Pdf-Gal4", "uas-DBTL","Pdf>DBTL"),
       col=c(alpha("gray77",0.9), alpha("gray45",0.8),alpha("gold3",0.8)),
       pch=16,cex=0.8,box.lty=0)

# Rose diagrams
rose.diag(cirradphases[,1],bins=12,col=alpha("gray77",0.3),
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,4],bins=12,col=alpha("gray45",0.3),
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,6],bins=12,col=alpha("gold3",0.3),
```

```
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
```

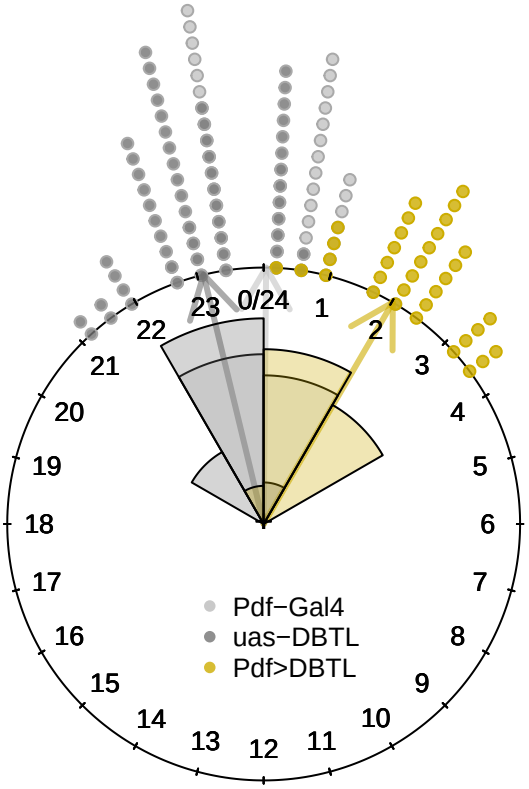

Figure 2: Circular plots and rose diagrams of Pdf-Gal4, uas-DBTL and Pdf>DBTL.

Plot 3: Pdf>DBTL, uas-UNC5 and pdf>DBTL,UNC5

In Figure 3, we show the raw circular data plots and rose diagrams of **Pdf>DBTL**, **uas-UNC5** and **pdf>DBTL,UNC5** based on the angles in radians, obtained from the phases.

```
# Plot 3
par(mar=c(rep(1,4)))
# plot the circular data for Pdf>DBTL [6] as a histogram with stack = TRUE
plot(cirradphases[,6], stack = TRUE, pch = 21, bg = alpha("gold3",0.8), col="gold3",
     cex=0.8, sep = 0.08, shrink = 2.2,
     main="Pdf>DBTL, uas-UNC5 and pdf>DBTL,UNC5",
     cex.main=0.8)

# calculate the circular means and point to them by arrows
circ.mean6<-mean(cirradphases[,6],na.rm = TRUE) # Pdf>DBTL [6]
circ.mean2<-mean(cirradphases[,2],na.rm = TRUE) # uas-UNC5 [2]
circ.mean7<-mean(cirradphases[,7],na.rm = TRUE) # pdf>DBTL,UNC5 [7]
```

```
# adding points for uas-UNC5 [2] and pdf>DBTL,UNC5 [7]
points(cirradphases[,2],stack = TRUE, pch = 21, bg = alpha("gray60",0.8),
       col = "darkgray", cex=0.8, sep=0.08)
points(cirradphases[,7],stack=TRUE, pch = 21, bg = alpha("gold4",0.8), col = "gold4",
       cex=0.8, sep=0.08)

# adding arrows to circular means
arrows.circular(circ.mean6, col = alpha("gold3",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean2, col = alpha("gray60",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean7, col = alpha("gold4",0.6), lwd=3) # arrow to circ. mean
legend(-0.4,-0.2,legend=c("Pdf>DBTL", "uas-UNC5","pdf>DBTL,UNC5"),
       col=c(alpha("gold3",0.8), alpha("gray60",0.8),alpha("gold4",0.8)),
       pch=16,cex=0.8,box.lty=0)

# Rose diagrams
rose.diag(cirradphases[,6],bins=12,col=alpha("gold3",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,2],bins=12,col=alpha("gray60",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,7],bins=12,col=alpha("gold4",0.3),
          cex=0.8,prop=0.95,add=TRUE,ticks=FALSE)
```

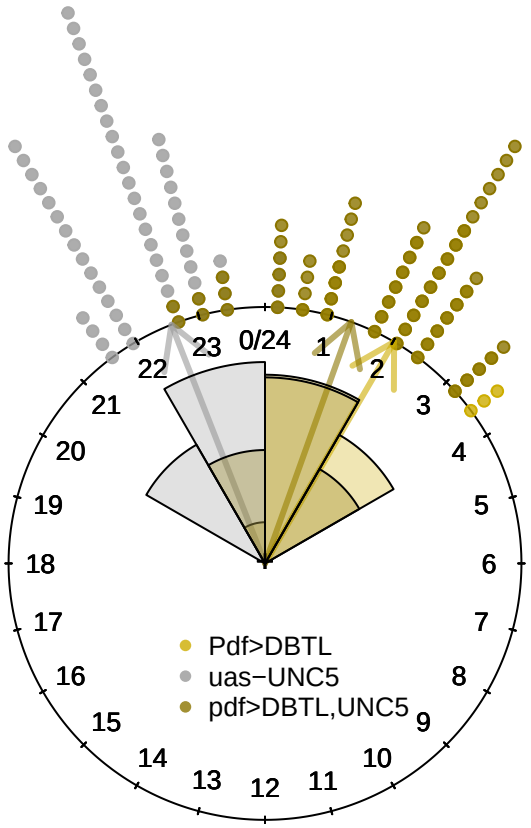

Figure 3: Circular plots and rose diagrams of Pdf>DBTL, uas-UNC5 and pdf>DBTL,UNC5.

Plot 4: Pdf>DBTL, uas-DBTL and pdf>DBTL,UNC5

In Figure 4, we show the raw circular data plots and rose diagrams of Pdf>DBTL, uas-DBTL and pdf>DBTL,UNC5, based on the angles in radians, obtained from the phases.

```
# Plot 4
par(mar=c(rep(1,4))) # set margins for the plots
# plot the circular data for Pdf>DBTL [6] as a histogram with stack = TRUE
plot(cirradphases[,6], stack = TRUE, pch = 21, bg = alpha("gold3",0.8), col="gold3",
     cex=0.8, sep = 0.08, shrink = 2.2,
     main="Pdf>DBTL, uas-DBTL and pdf>DBTL,UNC5",
     cex.main=0.8)

# calculate the circular means and point to them by arrows
circ.mean6<-mean(cirradphases[,6],na.rm = TRUE) # Pdf>DBTL [6]
circ.mean4<-mean(cirradphases[,4],na.rm = TRUE) # uas-DBTL [4]
circ.mean7<-mean(cirradphases[,7],na.rm = TRUE) # pdf>DBTL,UNC5 [7]

# adding points for uas-DBTL [4] and pdf>DBTL,UNC5 [7]
points(cirradphases[,4],stack = TRUE, pch = 21, bg = alpha("gray45",0.8),
       col = "darkgray", cex=0.8, sep=0.08)
points(cirradphases[,7],stack=TRUE, pch = 21, bg = alpha("gold4",0.8), col = "gold4",
       cex=0.8, sep=0.08)

# adding arrows to circular means
arrows.circular(circ.mean6, col = alpha("gold3",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean4, col = alpha("gray45",0.6), lwd=3) # arrow to circ. mean
arrows.circular(circ.mean7, col = alpha("gold4",0.6), lwd=3) # arrow to circ. mean
legend(-0.4,-0.2,legend=c("Pdf>DBTL", "uas-DBTL","pdf>DBTL,UNC5"),
       col=c(alpha("gold3",0.8), alpha("gray45",0.8),alpha("gold4",0.8)),
       pch=16,cex=0.8,box.lty=0)

# Rose diagrams
rose.diag(cirradphases[,6],bins=12,col=alpha("gold3",0.3),
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,4],bins=12,col=alpha("gray45",0.3),
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
rose.diag(cirradphases[,7],bins=12,col=alpha("gold4",0.3),
          cex=0.8,prop=0.88,add=TRUE,ticks=FALSE)
```

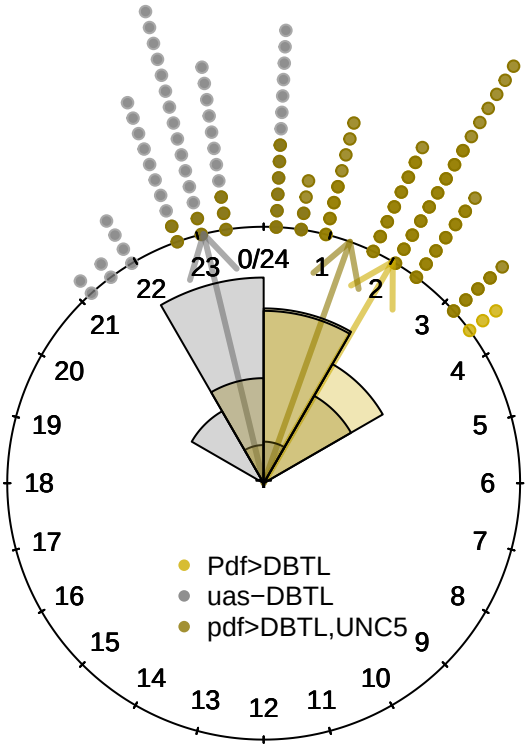

Figure 4: Circular plots and rose diagrams of Pdf>DBTL, uas-DBTL and pdf>DBTL,UNC5.