Tests of the efficiency of various fMRI designs

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Tests of the efficiency of various fMRI designs

Time-stamp: <2013-01-08 17:06 christophe@pallier.org>

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We present some simulations comparing the power of designs with fixed ISI to designs with varying ISI. We are interested in how precise are the estimates of the parameters associated to each condition.

```
## Loading required package: MASS


normalnoise <- function(npoints) {
    5 * rnorm(npoints)
}
```

Importing designs

Fixed SOA with empty trials

We load one schedule:

```
timing <- read.table("fMRI_Order_10.csv", sep = ",", col.names = c("onsets",
    "conditions", "durations"))
timing <- subset(timing, conditions <= 10)
plot_paradigm(timing)


(totalduration <- max(timing$onsets) + 10)


## [1] 770
```

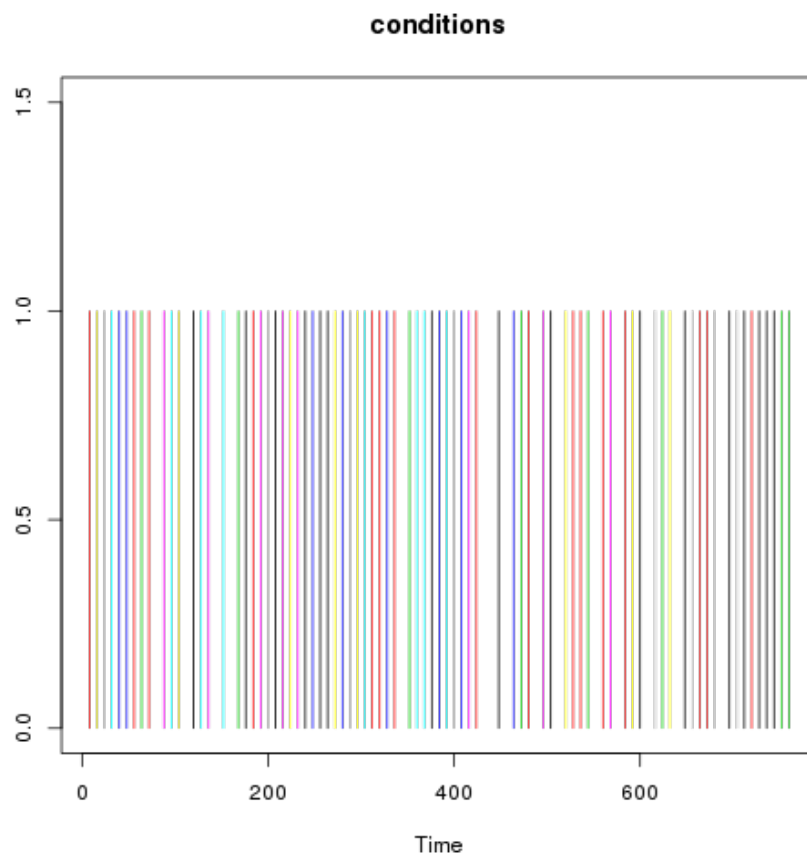Figure 1: plot of chunk unnamed-chunk-1

```
table(timing$conditions)
```

```
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```

```
X <- create_design_matrix(timing, totalduration)
plot_design_matrix(X)
```
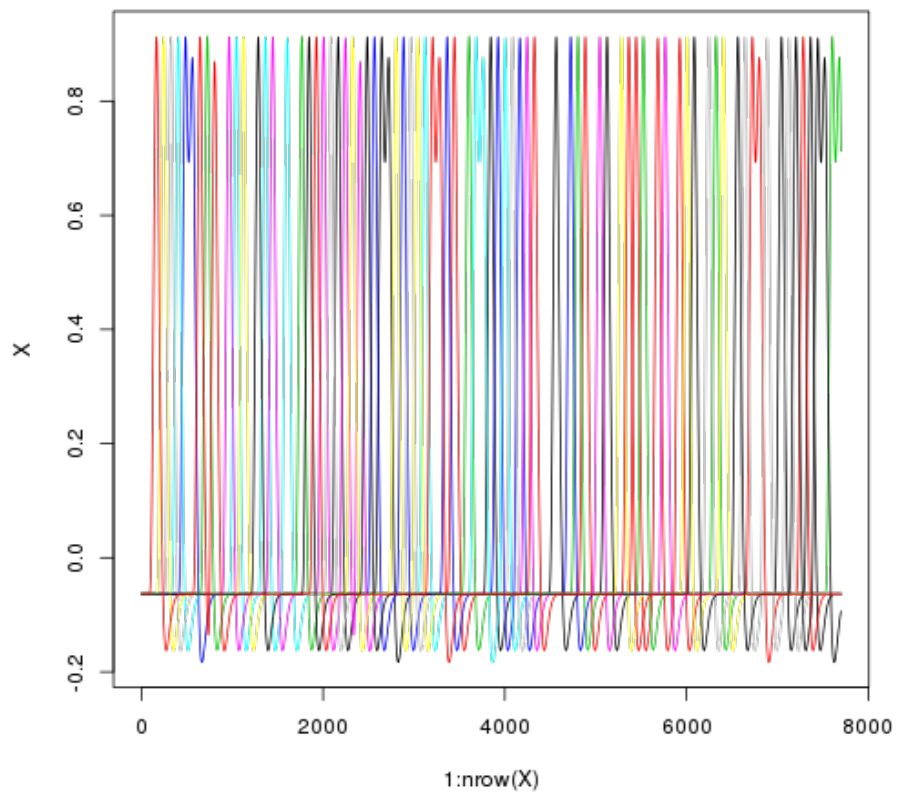
Figure 2: plot of chunk unnamed-chunk-1

```
betas <- c(1:5, -(1:5))
singlesimul(X, betas, list(lin = betas - mean(betas)), normalnoise)
```

```
## $estimates
##     XX1     XX2     XX3     XX4     XX5     XX6     XX7     XX8     XX9
##  1.3260  2.2491  3.7246  3.9339  5.4962 -0.8803 -1.6057 -2.5353 -3.8921
##    XX10
## -4.9380
##
## $estimatese
##    XX1    XX2    XX3    XX4    XX5    XX6    XX7    XX8    XX9   XX10
## 0.3055 0.3047 0.3045 0.3045 0.3022 0.3075 0.3054 0.3057 0.3058 0.3055
##
## $efficiencies
## [1] 3.597
##
```

Now, we load all schedules and report, for each, the estimates, their standard
errors, and the theoretical efficiency of the contrast c(1:5, -(1:5)).

```
for (csvfile in Sys.glob("fMRI_Order*.csv")) {
    timing <- read.table(csvfile, sep = ",", col.names = c("onsets", "conditions",
        "durations"))
    print("Totalduration")
    print(totalduration <- max(timing$onsets) + 10)
    print(table(timing$conditions))
    timing <- subset(timing, conditions <= 10)
    X <- create_design_matrix(timing, totalduration)
    betas <- c(1:5, -(1:5))
    cons <- list(lin = betas - mean(betas), beta1 = c(1, rep(0, ncol(X) - 1)))
    o <- singlesimul(X, betas, cons, normalnoise)
    print("Standard errors of estimates:")
    print(summary(as.numeric(o$estimatese)))
    print("Efficiency of linear contrast:")
    print("Efficiency of contrasts:")
    for (i in 1:length(cons)) {
        print(cons[i])
        print(o$efficiencies[i])
    }
}
```

```
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
```

```
##    0.297    0.299    0.300    0.300    0.300    0.302
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.597
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 272.2
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.302   0.306   0.306   0.306   0.307   0.310
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.575
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 267.9
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.297   0.298   0.299   0.300   0.301   0.306
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.625
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
```

```
## [1] 260.1
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.302   0.303   0.304   0.304   0.306   0.306
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.576
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 269.8
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.302   0.304   0.305   0.305   0.306   0.306
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.469
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 270
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.297   0.299   0.301   0.301   0.302   0.306
## [1] "Efficiency of linear contrast:"
```

```
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.609
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 272.8
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.301   0.304   0.306   0.305   0.307   0.307
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.661
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 274
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.296   0.298   0.300   0.300   0.303   0.306
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.634
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 277.1
## [1] "Totalduration"
```

```
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.302   0.306   0.307   0.307   0.307   0.311
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.574
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 273.1
## [1] "Totalduration"
## [1] 770
##
##  1  2  3  4  5  6  7  8  9 10 11 12
##  8  8  8  8  8  8  8  8  8  8  8  8
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.297   0.301   0.303   0.302   0.303   0.304
## [1] "Efficiency of linear contrast:"
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.639
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 270
```

sequences created by optseq

```
timing <- read.table("optseq/simcomp-001.par", col.names = c("onsets", "conditions",
    "durations", "weight", "condn"))
totalduration <- max(timing$onsets) + 10
timing <- subset(timing, conditions != 0)
print(table(timing$conditions))
```

```
##
```

```
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```

```
hist(diff(timing$onsets))
```


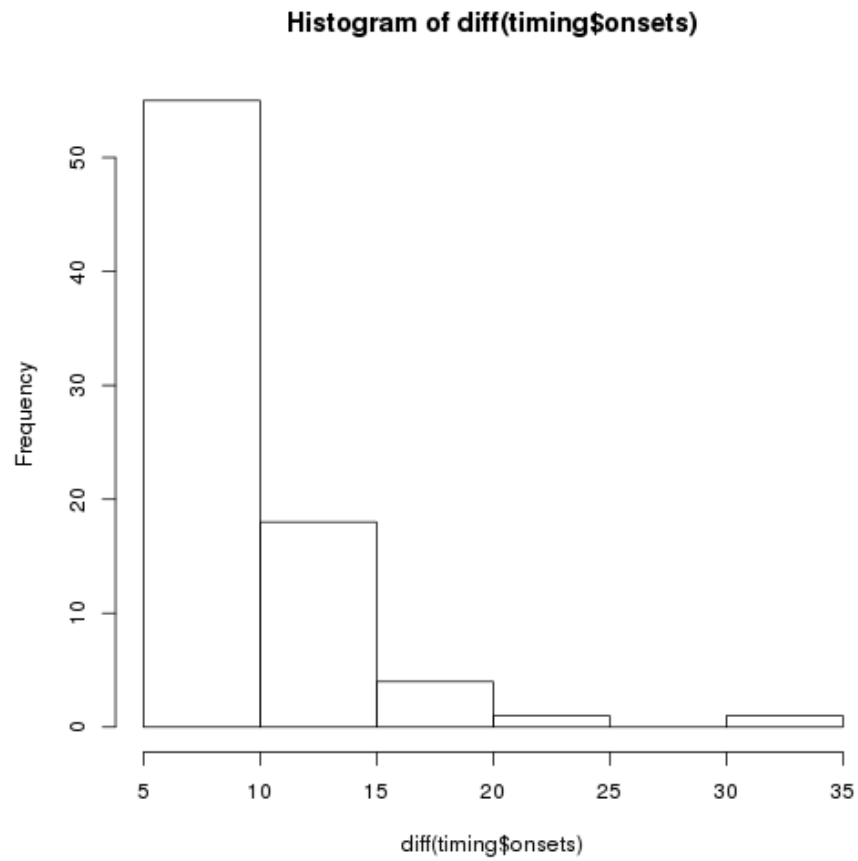**Histogram of diff(timing$onsets)**

Figure 3: plot of chunk unnamed-chunk-4

```
plot_paradigm(timing)
```

```
X <- create_design_matrix(timing, totalduration)
plot_design_matrix(X)
```
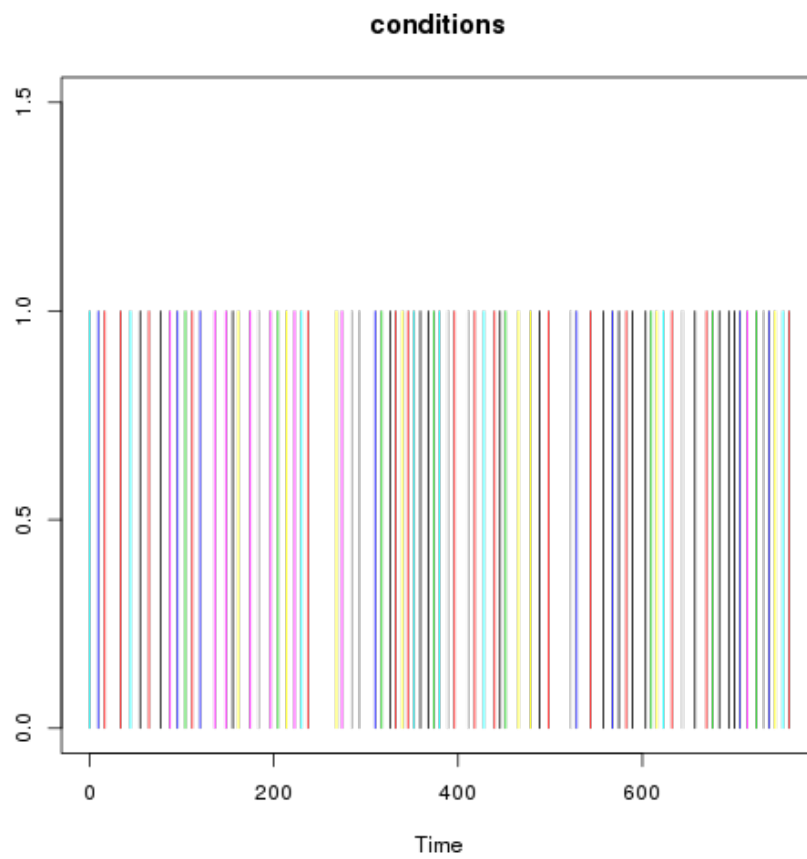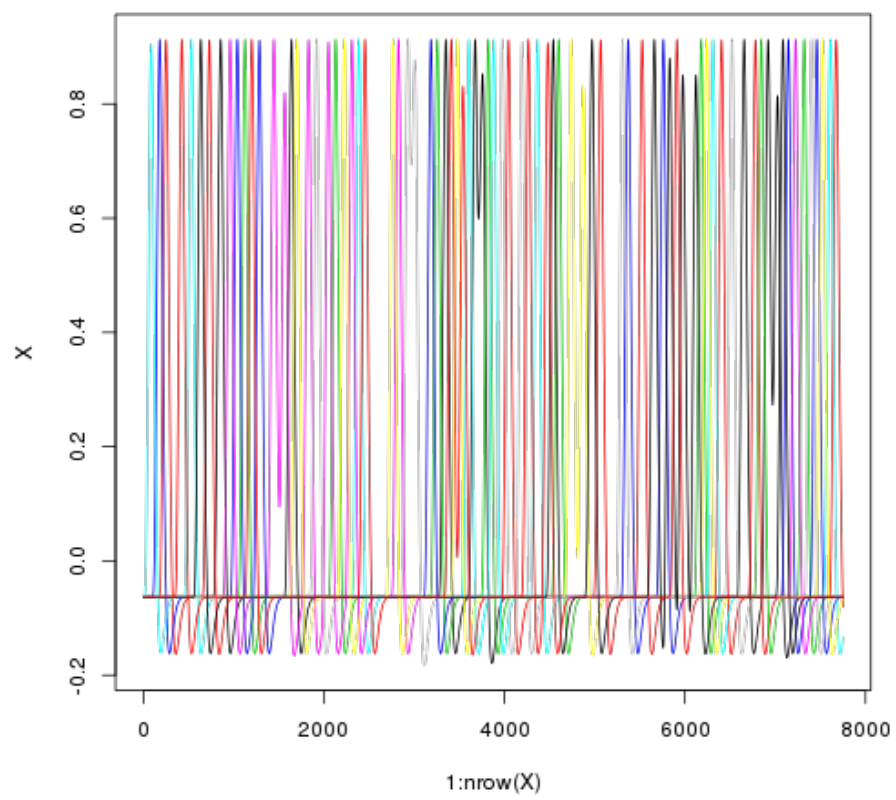
Figure 4: plot of chunk unnamed-chunk-4

Figure 5: plot of chunk unnamed-chunk-4

```
for (csvfile in Sys.glob("optseq/simcomp*.par")) {
    timing <- read.table(csvfile, col.names = c("onsets", "conditions", "durations",
        "weight", "condn"))
    totalduration <- max(timing$onsets) + 10
    timing <- subset(timing, conditions != 0)
    print(table(timing$conditions))
    hist(diff(timing$onsets))
    X <- create_design_matrix(timing, totalduration)
    cons <- list(lin = betas - mean(betas), beta1 = c(1, rep(0, ncol(X) - 1)))
    o <- singlesimul(X, betas, cons, normalnoise)
    print("Standard errors of estimates:")
    print(summary(as.numeric(o$estimatese)))
    print("Efficiency of contrasts:")
    for (i in 1:length(cons)) {
        print(cons[i])
        print(o$efficiencies[i])
    }
}
```

```
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8

## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.286   0.292   0.296   0.295   0.298   0.304
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.538
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 284.8
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8


## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.279   0.287   0.289   0.290   0.293   0.301
## [1] "Efficiency of contrasts:"
## $lin
```
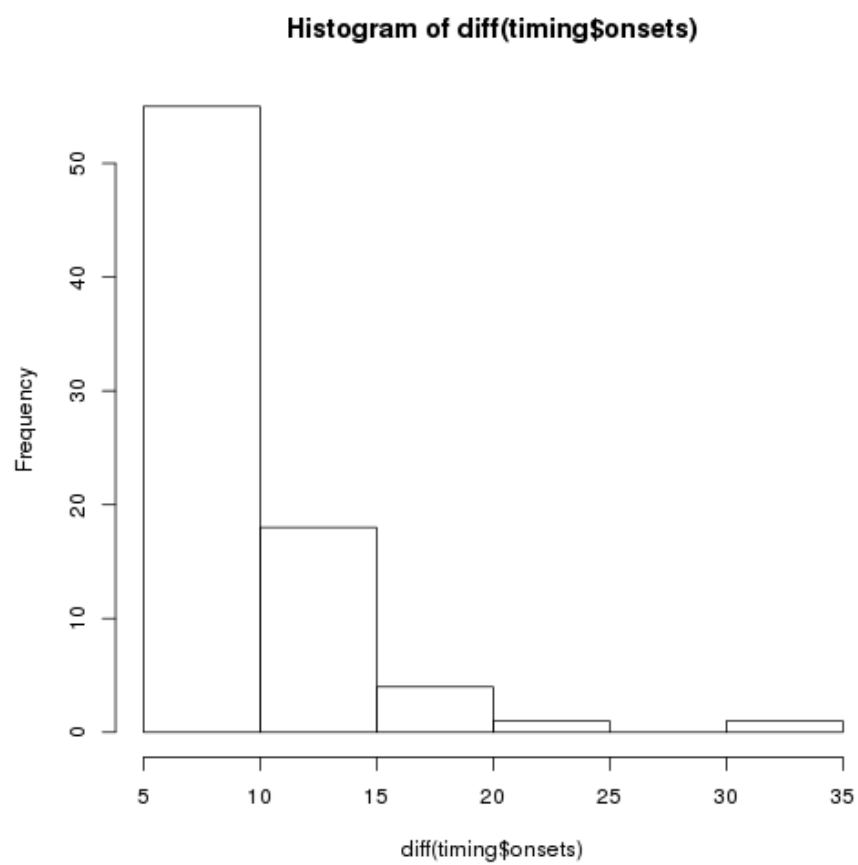
Figure 6: plot of chunk unnamed-chunk-5

```
## [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.651
## $beta1
## [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 314.4
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```
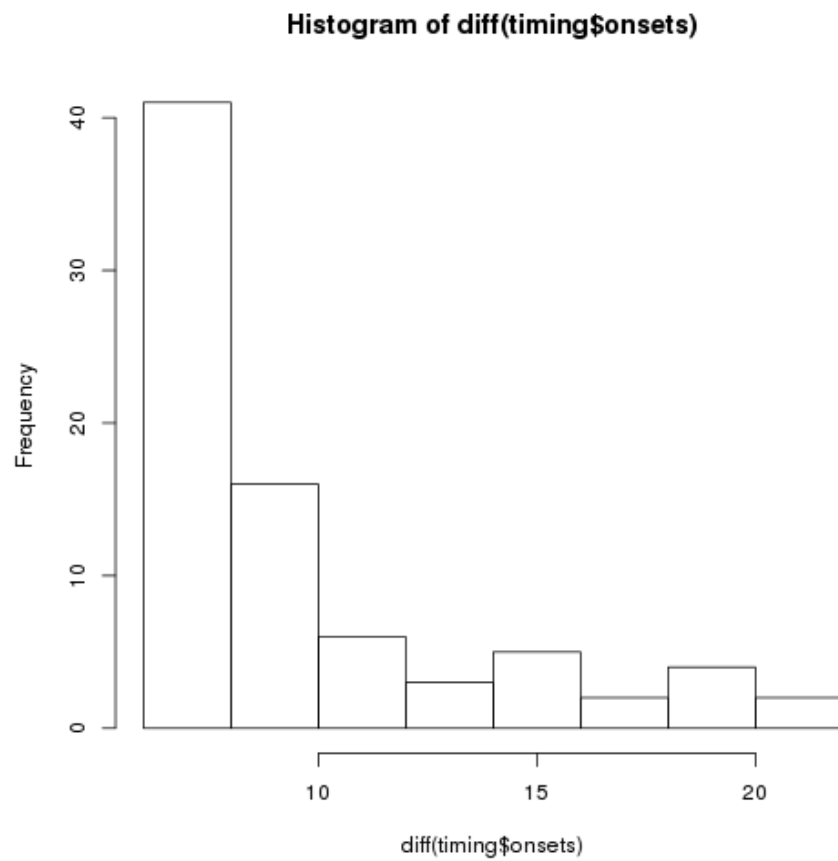
Histogram of diff(timing$onsets)

Figure 7: plot of chunk unnamed-chunk-5

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
```

14

```
##    0.284    0.290    0.292    0.293    0.297    0.301
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.486
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 289
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```
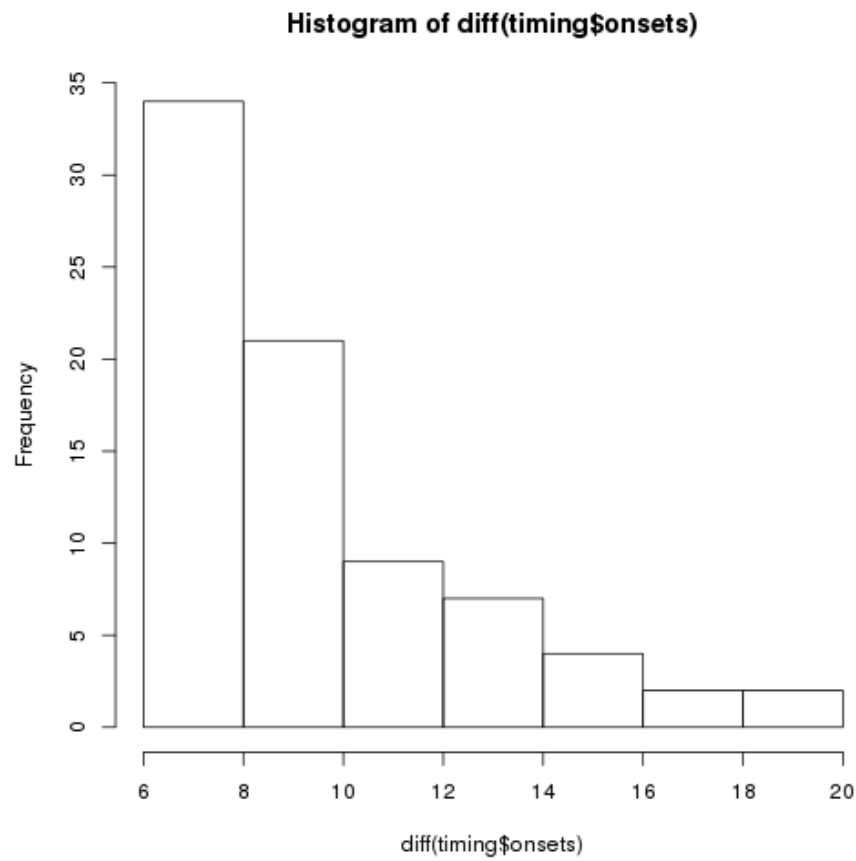
Histogram of diff(timing$onsets)

Figure 8: plot of chunk unnamed-chunk-5

15

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.261   0.275   0.282   0.279   0.286   0.289
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.666
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 306.5
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8


## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.278   0.287   0.290   0.290   0.293   0.296
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.744
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 292.3
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8


## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.276   0.281   0.286   0.285   0.287   0.293
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.565
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 302.4
```
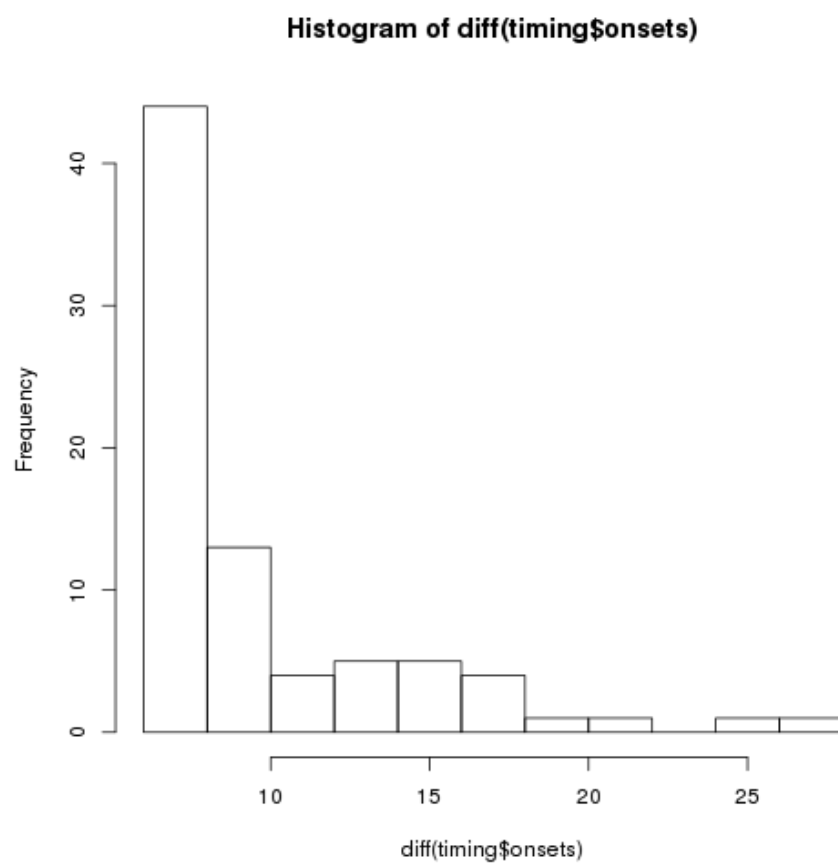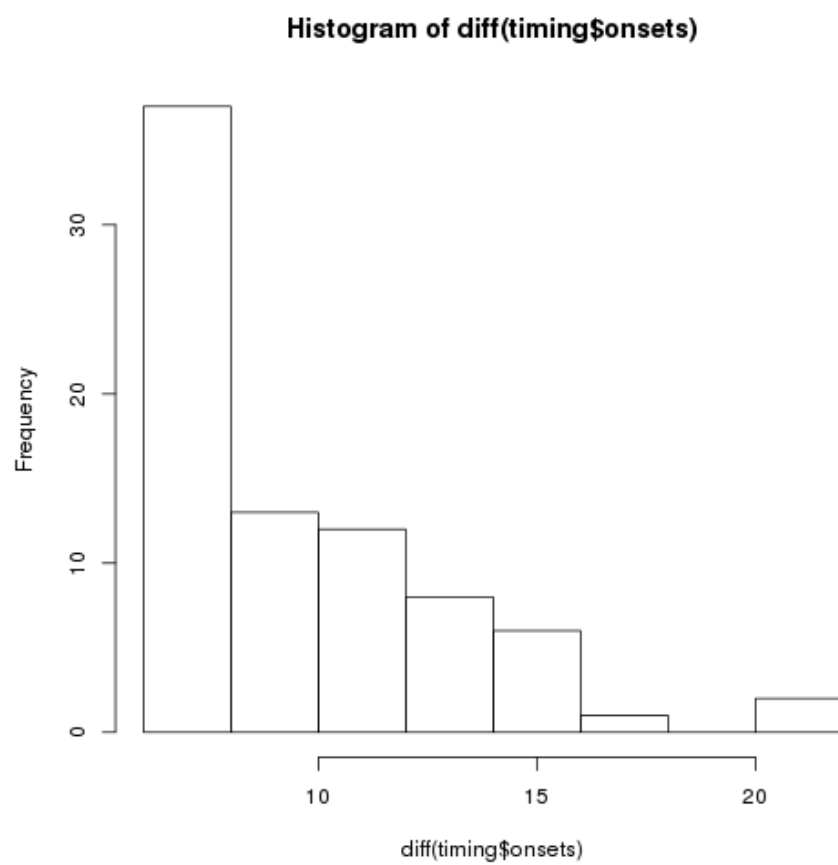
Histogram of diff(timing$onsets)

Figure 9: plot of chunk unnamed-chunk-5

Figure 10: plot of chunk unnamed-chunk-5

```
## 
## 1  2  3  4  5  6  7  8  9 10
## 8  8  8  8  8  8  8  8  8  8
```

Histogram of diff(timing$onsets)
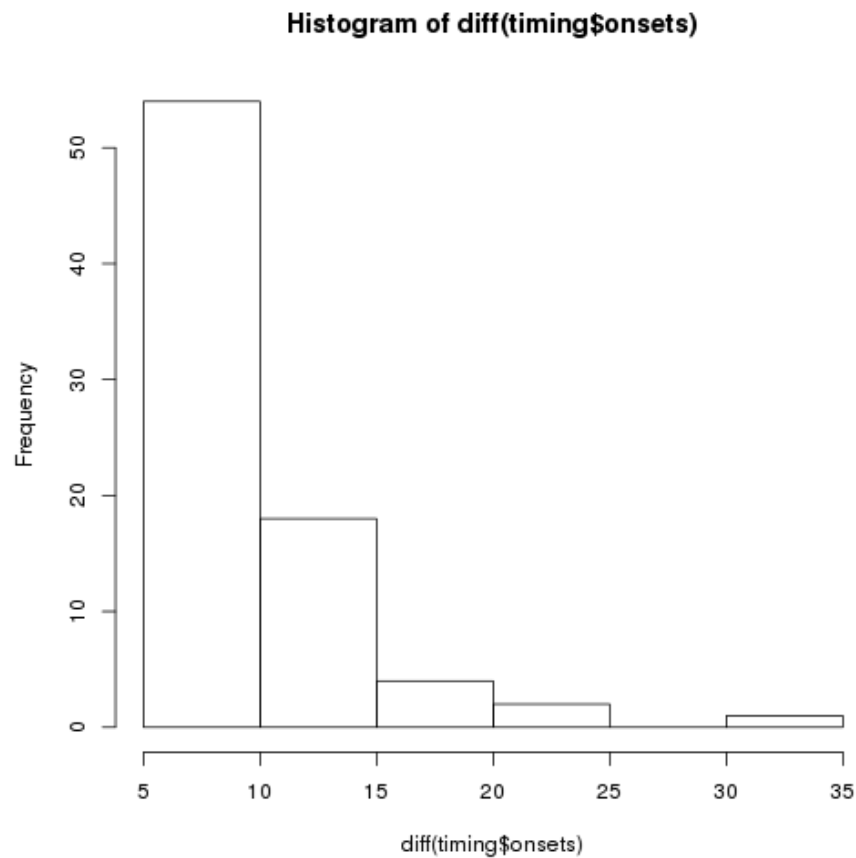

Figure 11: plot of chunk unnamed-chunk-5

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.285   0.289   0.292   0.292   0.296   0.299
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
## 
## [1] 3.785
## $beta1
```

```
## [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 301.5
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```

Histogram of diff(timing$onsets)
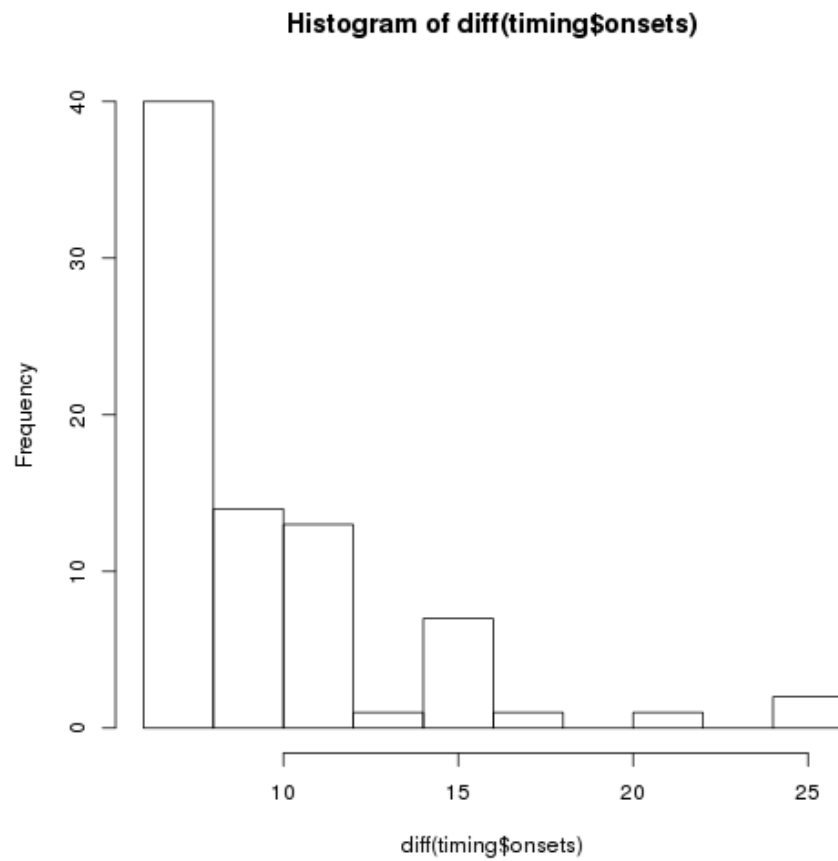

Figure 12: plot of chunk unnamed-chunk-5

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.294   0.296   0.303   0.300   0.303   0.306
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
```

```
## 
## [1] 3.366
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0
## 
## [1] 272.7
## 
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```

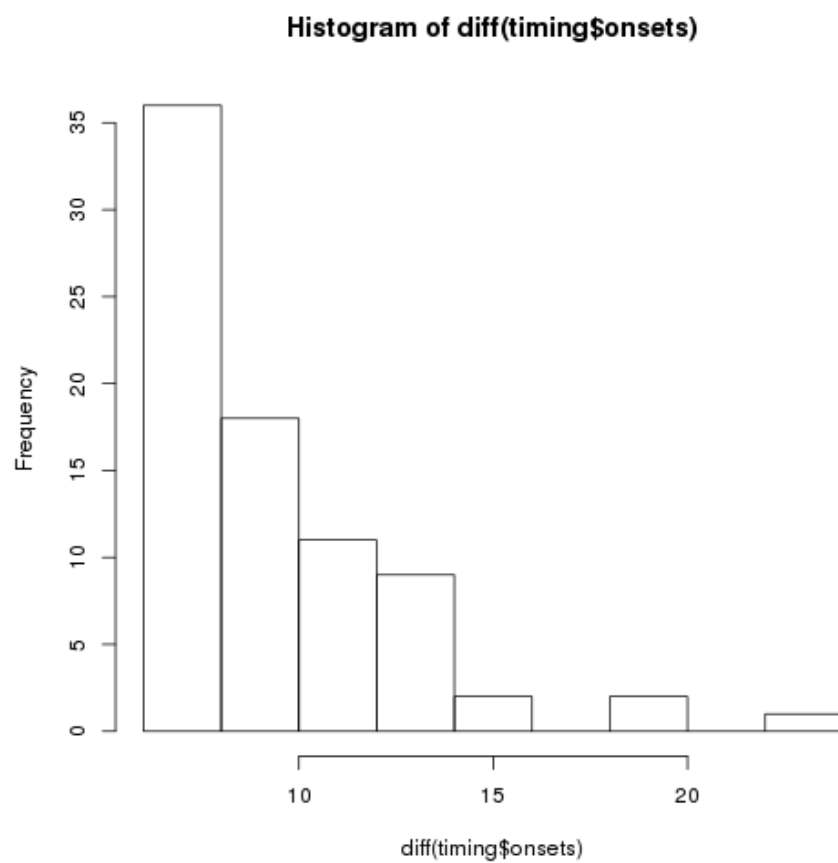**Histogram of diff(timing$onsets)**

Figure 13: plot of chunk unnamed-chunk-5

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.281   0.282   0.285   0.288   0.292   0.305
```

```
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.707
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 304.5
##
##  1  2  3  4  5  6  7  8  9 10
##  8  8  8  8  8  8  8  8  8  8
```

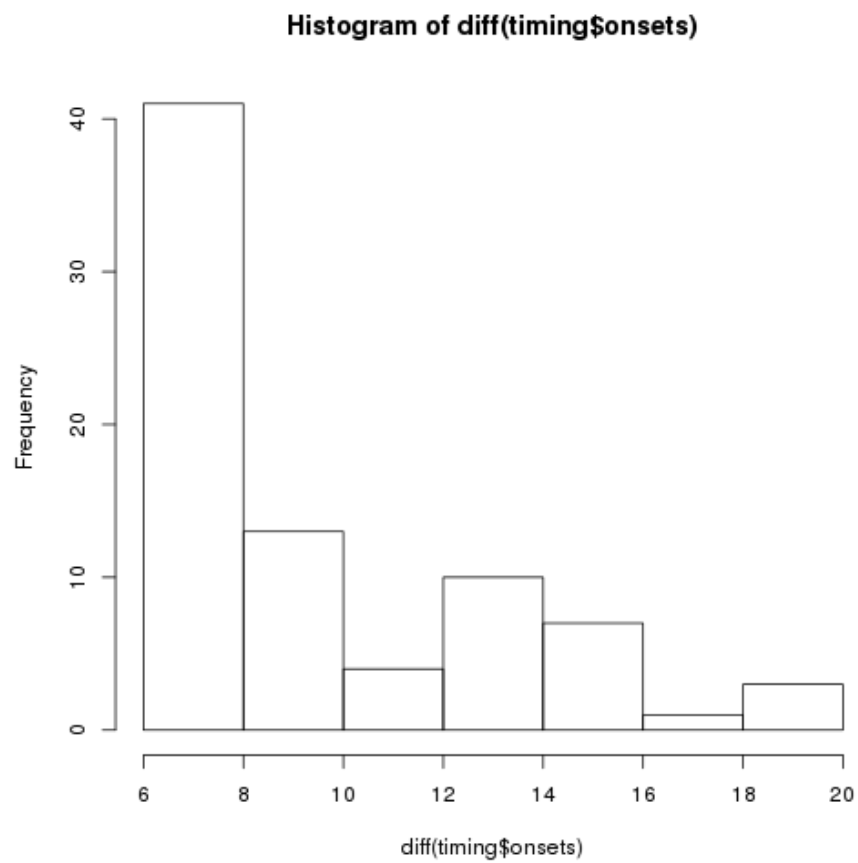**Histogram of diff(timing$onsets)**

Figure 14: plot of chunk unnamed-chunk-5

```
## [1] "Standard errors of estimates:"
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.282   0.295   0.295   0.294   0.296   0.300
## [1] "Efficiency of contrasts:"
## $lin
##  [1]  1  2  3  4  5 -1 -2 -3 -4 -5
##
## [1] 3.384
## $beta1
##  [1] 1 0 0 0 0 0 0 0 0 0
##
## [1] 317.3
```
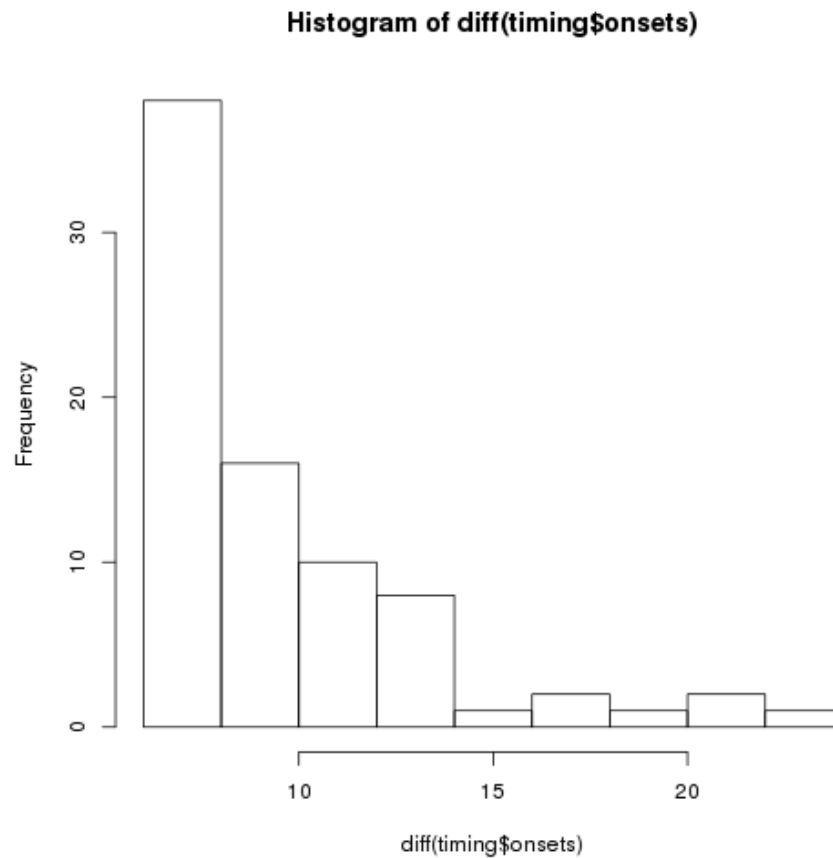

Figure 15: plot of chunk unnamed-chunk-5