The Development of Polarity Subjunctive

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Contents

1. Introduction

This file shows the code used to create the figures of the behavior of the different functions used in Chapter 5 of the thesis entitled "Mood alternations: a synchronic and diachronic study of negated complement clauses". The rest of materials can be found at: https://github.com/Raquel-Montero

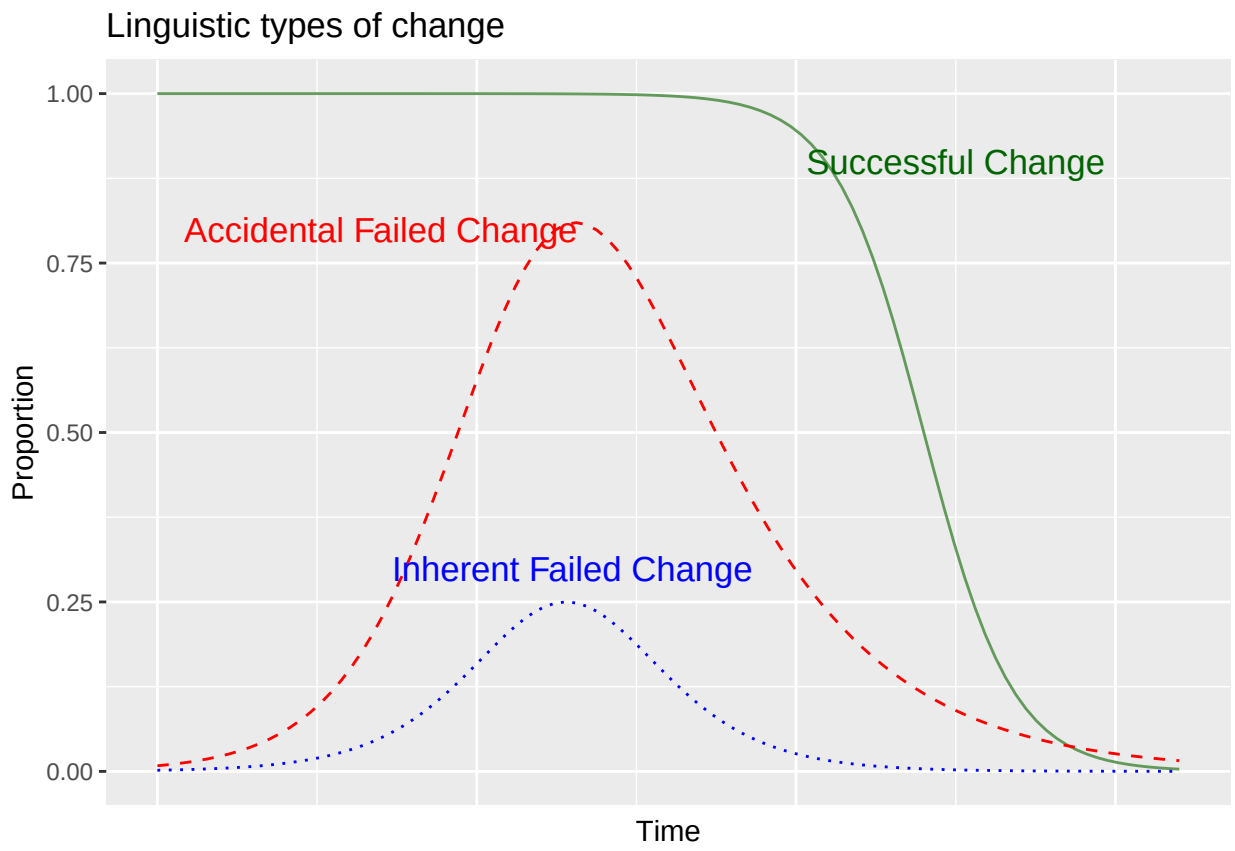
Packages that will be used:

```
library(readr)
library(carData)      # for cat package
library(car)          # Anova function
library(dplyr)        # Operations
library(plyr)         # for ddply
library(ggplot2)      # to use ggplot
library(sjPlot)       # to change the font
library(Matrix)       # for lme4 package
library(lme4)         # to calculate lmer models
library(lmerTest)     # for the p values
library(mgcv)         # for Gam model
library(itsadug)      # for Gam model
library(tidygam)      # for Gam plotting
library(tidymv)       # For Gam plotting: https://www.rdocumentation.org/packages/tidymv/versions/3.4.2
library(ggpubr)
library(LaplacesDemon) #for the function invlogit
library(grid)
```

2. Functions: Types of change

```
logistic <- function(x){(1/(1+exp((x-12)/0.7)))}
inherent.failed <- function(x){(exp(-(x-6.4)/(1)))/(1+exp(-(x-6.4)/(1)))^2}
accidental.failed <- function(x){(exp(-(x-7.7)/(2)))/(1+exp(-(x-5.6)/(1.3)))^2}

# Plot 1:
plot.types.change <- ggplot()+
                geom_function(fun=logistic, color = "#4c8c44d9")+ # Sucessful Change
```

```
                geom_function(fun=inherent.failed, color = "blue", linetype="dotted")+ # Sucessful Chan
                 geom_function(fun=accidental.failed, color = "red", linetype="dashed")+ # Sucessful Ch
                labs(title="Linguistic types of change",  # axis
                      x = "Time",
                       y="Proportion")+
                theme(axis.text.x=element_blank(),
                      axis.ticks.x=element_blank())+
                ylim(0,1)+
                xlim(0,16)+
                annotate("text", x = 3.5, y = 0.8,
                         label = "Accidental Failed Change",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/2.5,
                         color="red"
                         )+
               annotate("text", x = 6.5, y = 0.3,
                         label = "Inherent Failed Change",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/2.5,
                         color="blue"
                        )+
              annotate("text", x = 12.5, y = 0.9,
                         label = "Successful Change",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/2.5,
                         color="darkgreen"
                        )


plot.types.change
```



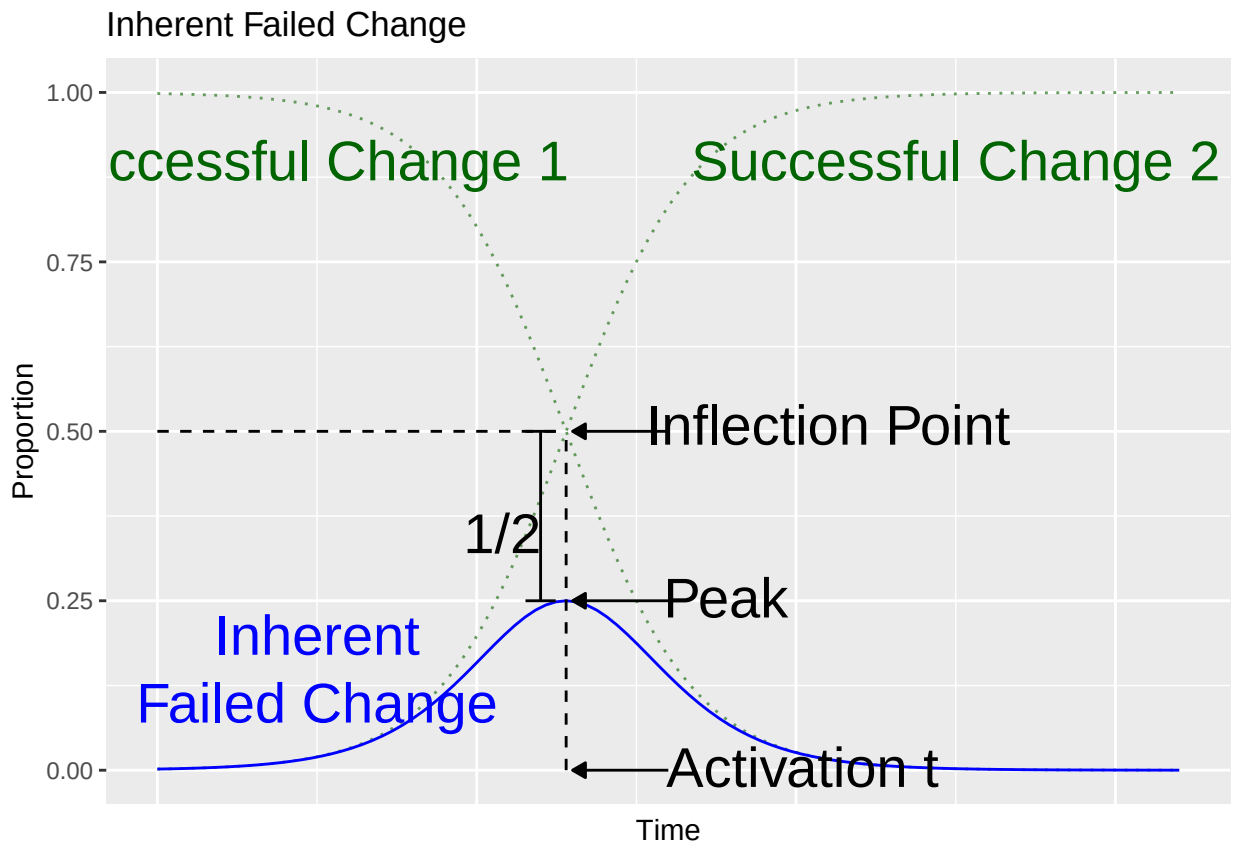

```
ggsave(plot.types.change, file="TypeChanges.png", width = 8, height = 5)
```

2.1. Failed changes

```
logistic1 <- function(x){(1/(1+exp((x-6.4)/1)))}
logistic2 <- function(x){(1/(1+exp(-(x-6.4)/1)))}
inherent.failed2 <- function(x){(exp(-(x-6.4)/(1)))/(1+exp(-(x-6.4)/(1)))^2}

plot.inherent.fail <- ggplot()+
                geom_function(fun=logistic1, color = "#4c8c44d9",linetype="dotted")+ # Sucessful Change
                geom_function(fun=logistic2, color = "#4c8c44d9",linetype="dotted")+ # Sucessful Change
                geom_function(fun=inherent.failed2, color = "blue")+ # Sucessful Change
                #geom_function(fun=accidental.failed, color = "red", linetype="dashed")+ # Sucessful Ch
                labs(title="Inherent Failed Change",  # axis
                      x = "Time",
                       y="Proportion")+
                theme(axis.text.x=element_blank(),
                      axis.ticks.x=element_blank())+
                ylim(0,1)+
                xlim(0,16)+
                annotate("text", x = 2.3, y = 0.9,
                         label = "Successful Change 1",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="darkgreen"
                         )+
```

```
   annotate("text", x = 2.5, y = 0.2,
            label = "Inherent",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="blue"
           )+
  annotate("text", x = 2.5, y = 0.1,
            label = "Failed Change",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="blue"
           )+
  annotate("text", x = 12.5, y = 0.9,
            label = "Successful Change 2",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="darkgreen"
           )+
 annotate("text", x = 10.5, y = 0.51,
            label = "Inflection Point",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="black"
           )+
 annotate("text", x = 8.9, y = 0.255,
            label = "Peak",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="black"
           )+
annotate("text", x = 5.4, y = 0.35,
            label = "1/2",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="black"
           )+
annotate("text", x = 10.1, y = 0.005,
            label = "Activation t",
            family= theme_get()$text[["family"]],
             size= theme_get()$text[["size"]]/1.5,
            color="black"
           )+
 geom_segment(aes(x = 0, y = 0.5, xend = 6.4, yend = 0.5), linetype="dashed")+
geom_segment(aes(x = 6.4, y = 0, xend = 6.4, yend = 0.5), linetype="dashed")+
 annotate("segment", x = 8, y = 0.5, xend = 6.5, yend = 0.5,
         arrow = arrow(type = "closed", length = unit(0.02, "npc")))+
annotate("segment", x = 8, y = 0.25, xend = 6.5, yend = 0.25,
         arrow = arrow(type = "closed", length = unit(0.02, "npc")))+
annotate("segment", x = 8, y = 0, xend = 6.5, yend = 0,
         arrow = arrow(type = "closed", length = unit(0.02, "npc")))+
 annotate("segment", x = 6, y = 0.25, xend = 6, yend = 0.5,
         arrow = arrow(ends = "both", angle = 90, length = unit(.2,"cm")))
```

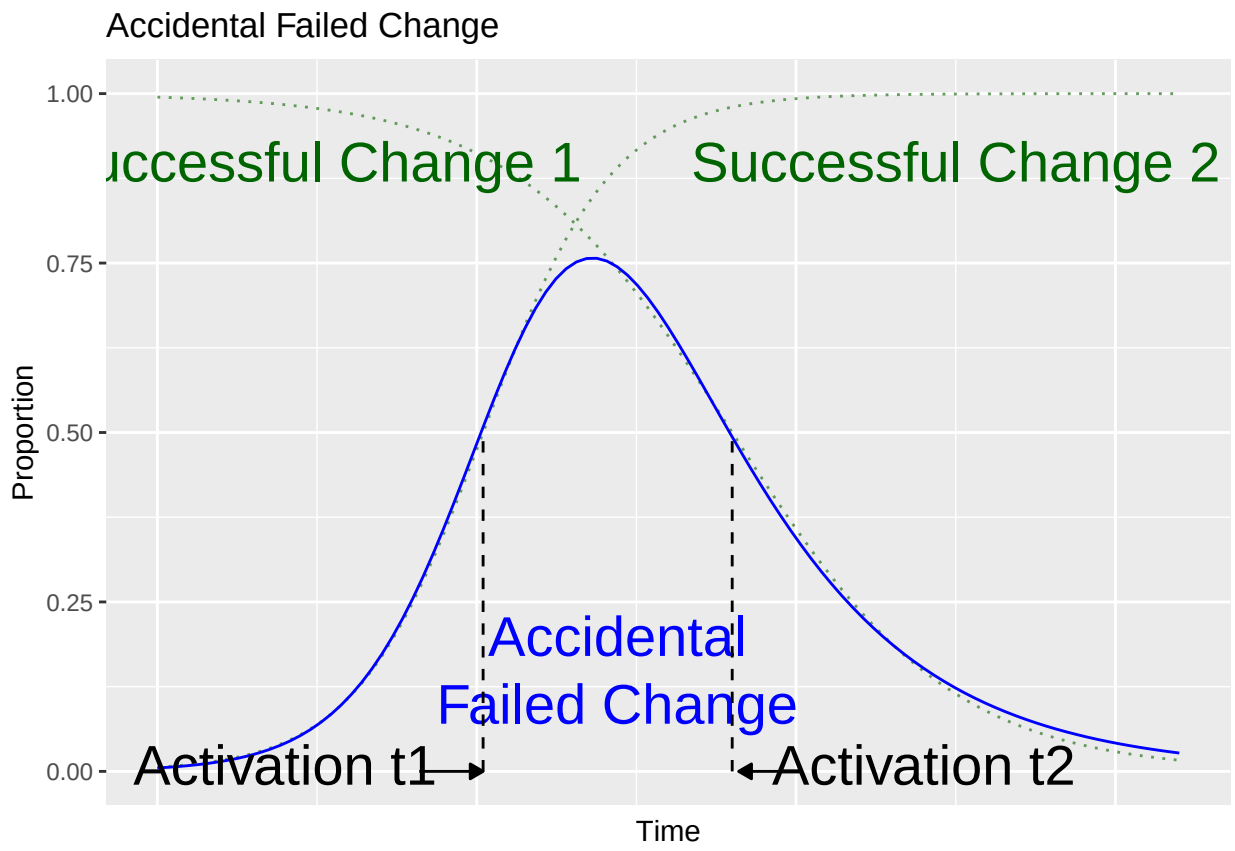
```
plot.inherent.fail
```



Accidental failed changes:

```
logistic4 <- function(x){(1/(1+exp((x-9)/1.71)))}
logistic5 <- function(x){(1/(1+exp(-(x-5.1)/1)))}
accidental.failed2 <- function(x){(exp(-(x-7.7)/(2.3)))/(1+exp(-(x-5.6)/(1.3)))^2}

plot.accidental.fail <- ggplot()+
                geom_function(fun=logistic4, color = "#4c8c44d9",linetype="dotted")+ # Sucessful Change
                geom_function(fun=logistic5, color = "#4c8c44d9",linetype="dotted")+ # Sucessful Change
                geom_function(fun=accidental.failed2, color = "blue")+ # Sucessful Change
                #geom_function(fun=accidental.failed, color = "red", linetype="dashed")+ # Sucessful Ch
                labs(title="Accidental Failed Change",  # axis
                      x = "Time",
                       y="Proportion")+
                theme(axis.text.x=element_blank(),
                      axis.ticks.x=element_blank())+
                ylim(0,1)+
                xlim(0,16)+
                annotate("text", x = 2.5, y = 0.9,
                         label = "Successful Change 1",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="darkgreen"
```

```
                    )+
  annotate("text", x = 7.2, y = 0.2,
                    label = "Accidental",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="blue"
                   )+
 annotate("text", x = 7.2, y = 0.1,
                    label = "Failed Change",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="blue"
                   )+
annotate("text", x = 12, y = 0.01,
                    label = "Activation t2",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="black"
                   )+
 annotate("text", x = 2, y = 0.01,
                    label = "Activation t1",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="black"
                   )+
annotate("text", x = 12.5, y = 0.9,
                    label = "Successful Change 2",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="darkgreen"
                   )+
geom_segment(aes(x = 9, y = 0, xend = 9, yend = 0.5), linetype="dashed")+
geom_segment(aes(x = 5.1, y = 0, xend = 5.1, yend = 0.5), linetype="dashed")+
annotate("segment", x = 10, y = 0, xend = 9.1, yend = 0,
       arrow = arrow(type = "closed", length = unit(0.02, "npc")))+
annotate("segment", x = 4.1, y = 0, xend = 5.1, yend = 0,
       arrow = arrow(type = "closed", length = unit(0.02, "npc")))



plot.accidental.fail
```

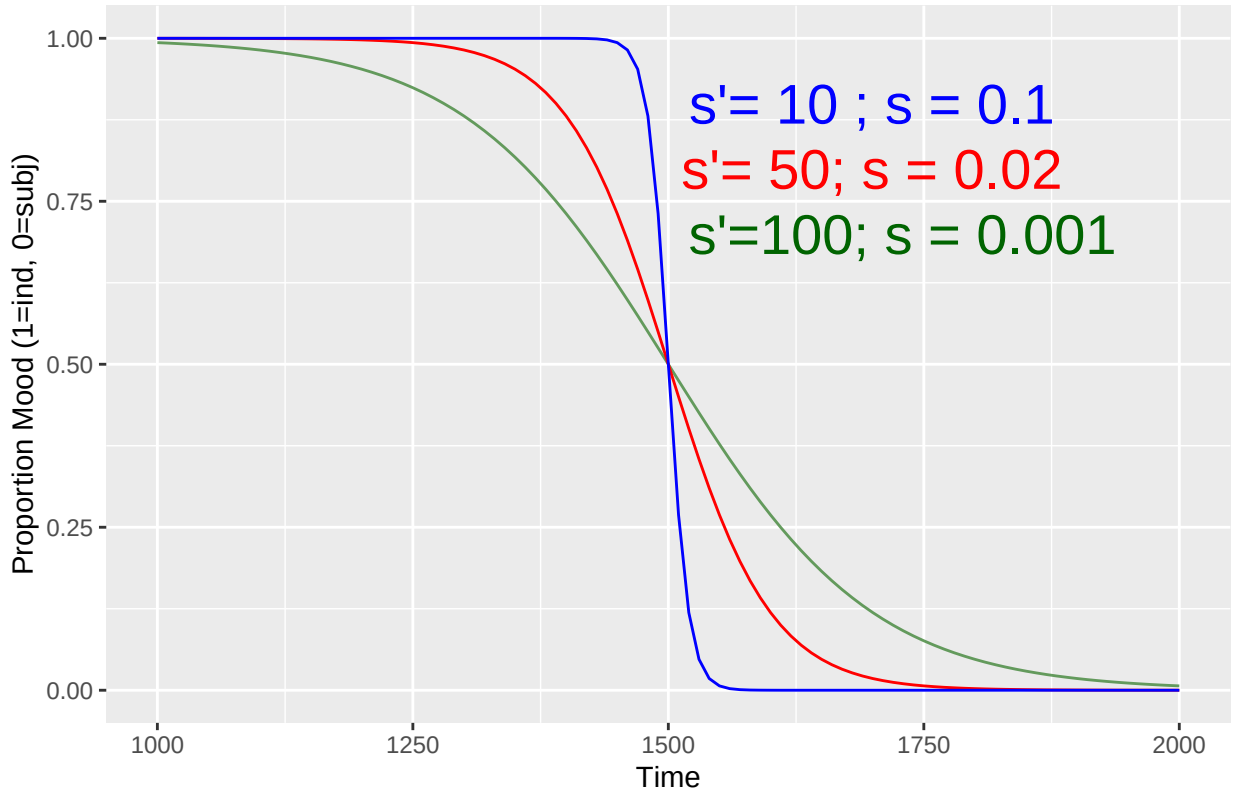



```
combined.failed <- ggarrange(plot.inherent.fail,plot.accidental.fail,ncol = 2)
ggsave(combined.failed, file="failed-changes.png",width = 16, height = 5)
```

3. Logistic

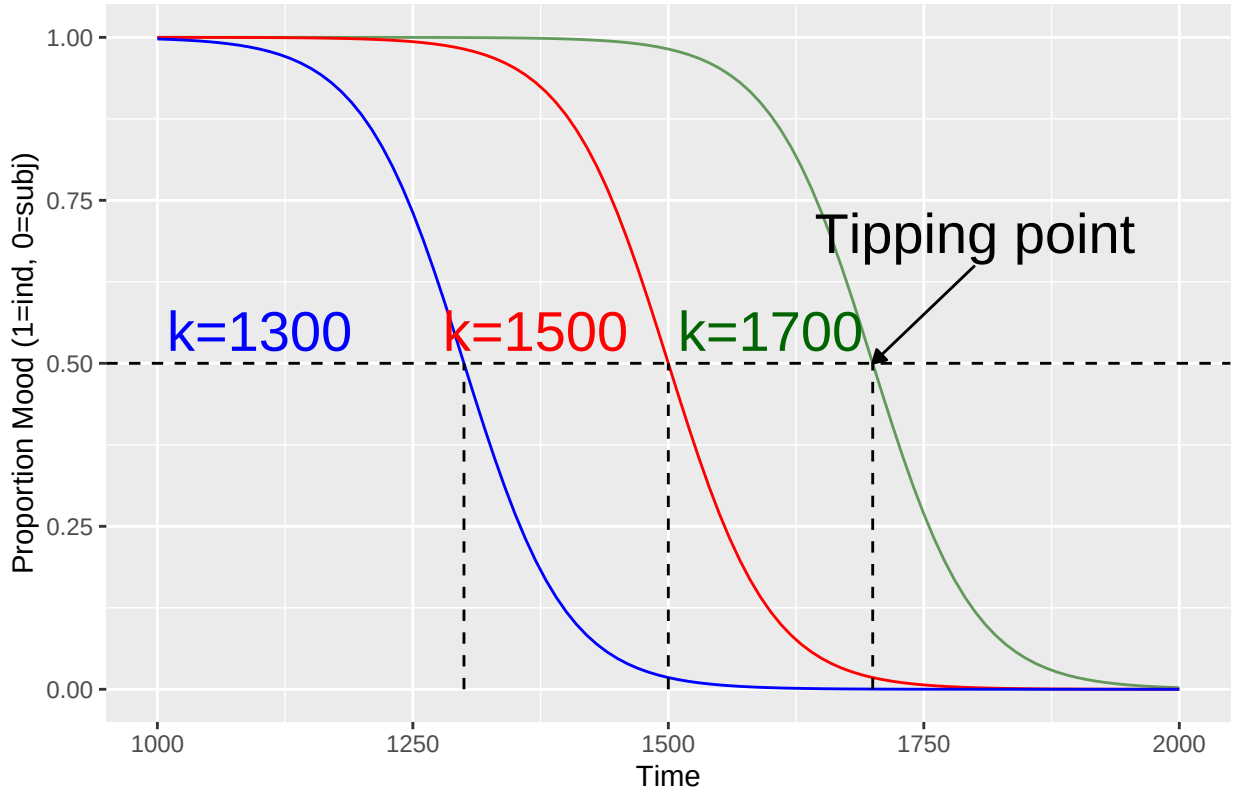
```
logistic1 <- function(x){(1/(1+exp((x-1500)/100)))}
logistic2 <- function(x){(1/(1+exp((x-1500)/50)))}
logistic3 <- function(x){(1/(1+exp((x-1500)/10)))}

plot.logistic1 <- ggplot()+
                  geom_function(fun=logistic1, color = "#4c8c44d9")+ # Sucessful Change
                  geom_function(fun=logistic2, color = "red")+ # Sucessful Change
                  geom_function(fun=logistic3, color = "blue")+ # Sucessful Change
                  labs(title="",  # axis
                        x = "Time",
                         y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                  xlim(1000,2000)+
                  annotate("text", x = 1700, y = 0.8,
                           label = "s'= 50; s = 0.02",
                           family= theme_get()$text[["family"]],
                            size= theme_get()$text[["size"]]/1.5,
                           color="red"
                           )+
                annotate("text", x = 1700, y = 0.9,
```

```
                        label = "s'= 10 ; s = 0.1",
                        family= theme_get()$text[["family"]],
                         size= theme_get()$text[["size"]]/1.5,
                        color="blue"
                       )+
              annotate("text", x = 1730, y = 0.7,
                        label = "s'=100; s = 0.001",
                        family= theme_get()$text[["family"]],
                         size= theme_get()$text[["size"]]/1.5,
                        color="darkgreen"
                       )


plot.logistic1
```



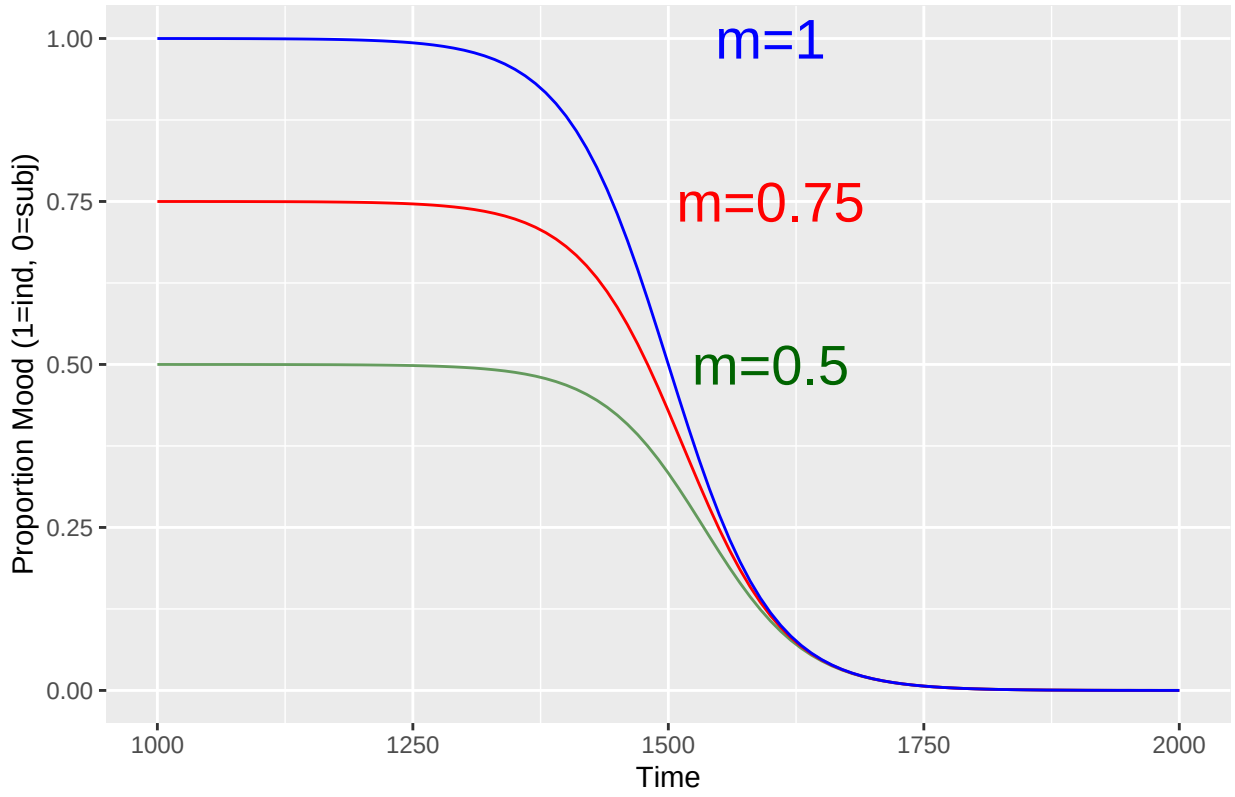

```
# A change with s'=100 years  would take 1000 years to complete. That is every 100 years there is 10% l
# A change with an s'= 50 would take 500 years to complete. That is every 50 years there is 10% less of
# A change with an s'= 10 would take 100 years to complete. That is every 10 years there is 10% less of

logistic4 <- function(x){(1/(1+exp((x-1700)/50)))}
logistic5 <- function(x){(1/(1+exp((x-1500)/50)))}
logistic6 <- function(x){(1/(1+exp((x-1300)/50)))}


plot.logistic2 <- ggplot()+
                  geom_function(fun=logistic4, color = "#4c8c44d9")+ # Sucessful Change
```

```
                geom_function(fun=logistic5, color = "red")+ # Sucessful Change
                geom_function(fun=logistic6, color = "blue")+ # Sucessful Change
                labs(title="",  # axis
                      x = "Time",
                       y="Proportion Mood (1=ind, 0=subj)")+
                ylim(0,1)+
                xlim(1000,2000)+
                annotate("text", x = 1370, y = 0.55,
                         label = "k=1500",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="red"
                         )+
               annotate("text", x = 1100, y = 0.55,
                         label = "k=1300",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="blue"
                        )+
              annotate("text", x = 1600, y = 0.55,
                         label = "k=1700",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="darkgreen"
                        )+
            annotate("text", x = 1800, y = 0.7,
                     label = "Tipping point",
                     family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                     color="black"
                                )+
            geom_hline(yintercept=0.5, linetype="dashed", color = "black")+
            geom_segment(aes(x = 1500, y = 0, xend = 1500, yend = 0.5), linetype="dashed")+
            geom_segment(aes(x = 1300, y = 0, xend = 1300, yend = 0.5), linetype="dashed")+
             geom_segment(aes(x = 1700, y = 0, xend = 1700, yend = 0.5), linetype="dashed")+
            annotate("segment", x = 1800, y = 0.65, xend = 1700, yend = 0.5,
                    arrow = arrow(type = "closed", length = unit(0.02, "npc")))


plot.logistic2
```




```
logistic7 <- function(x){(1/((1/0.5)+exp((x-1500)/50)))}
logistic8 <- function(x){(1/((1/0.75)+exp((x-1500)/50)))}
logistic9 <- function(x){(1/((1/1)+exp((x-1500)/50)))}

plot.logistic3 <- ggplot()+
                  geom_function(fun=logistic7, color = "#4c8c44d9")+ # Sucessful Change
                  geom_function(fun=logistic8, color = "red")+ # Sucessful Change
                  geom_function(fun=logistic9, color = "blue")+ # Sucessful Change
                  labs(title="",  # axis
                        x = "Time",
                         y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                  xlim(1000,2000)+
                  annotate("text", x = 1600, y = 0.75,
                           label = "m=0.75",
                           family= theme_get()$text[["family"]],
                            size= theme_get()$text[["size"]]/1.5,
                           color="red"
                           )+
                 annotate("text", x = 1600, y = 1,
                           label = "m=1",
                           family= theme_get()$text[["family"]],
                            size= theme_get()$text[["size"]]/1.5,
                           color="blue"
                          )+
                annotate("text", x = 1600, y = 0.50,
```

```
                          label = "m=0.5",
                          family= theme_get()$text[["family"]],
                           size= theme_get()$text[["size"]]/1.5,
                          color="darkgreen"
                         )


plot.logistic3
```




```
combined.logistic <- ggarrange(plot.logistic1,plot.logistic2,plot.logistic3,ncol = 3)
```

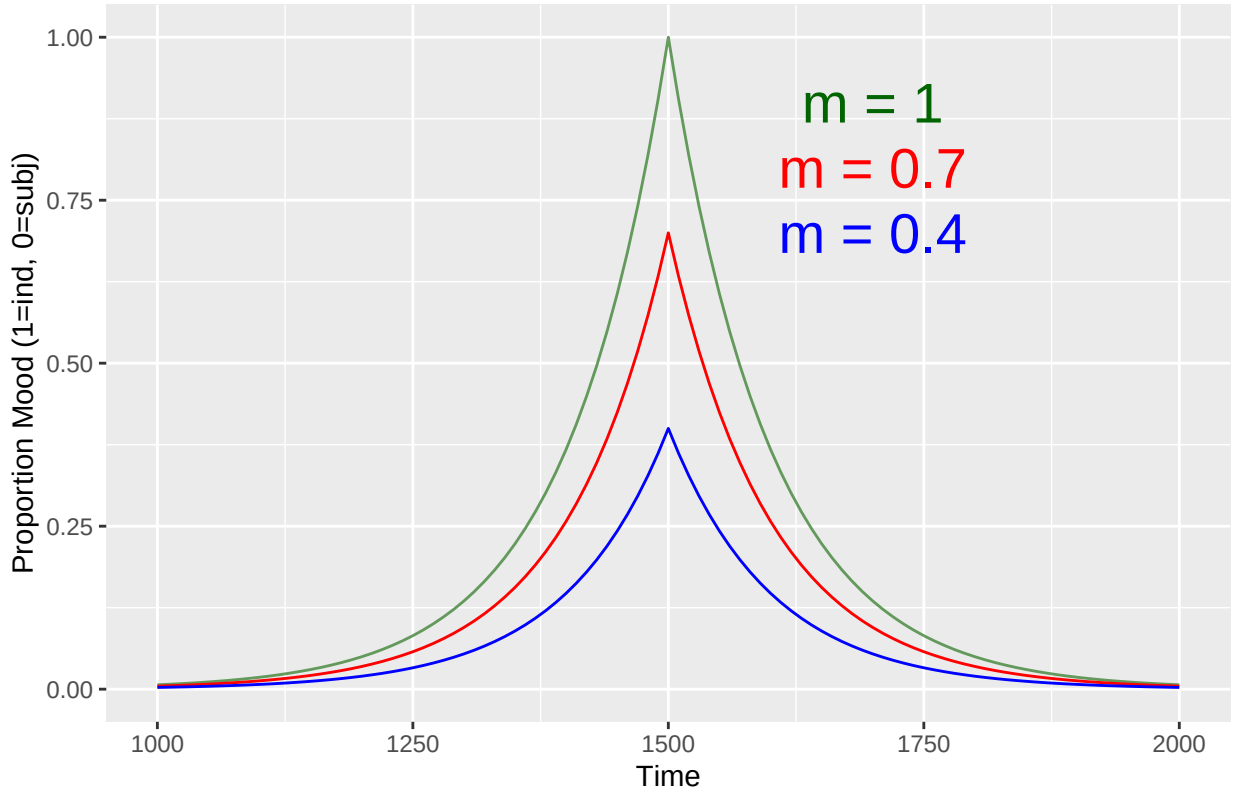
```
ggsave(combined.logistic, file="logistic-parameters.png",width = 16, height = 5)
```

4. Laplace function

```
laplace1 <- function(x){1*exp(-abs(x-1500)/100)}
laplace2 <- function(x){0.7*exp(-abs(x-1500)/100)}
laplace3 <- function(x){0.4*exp(-abs(x-1500)/100)}

plot.laplace1 <- ggplot()+
                 geom_function(fun=laplace1, color = "#4c8c44d9")+
                 geom_function(fun=laplace2, color = "red")+
                geom_function(fun=laplace3, color = "blue")+
                 labs(title="",  # axis
                      x = "Time",
                      y="Proportion Mood (1=ind, 0=subj)")+
```

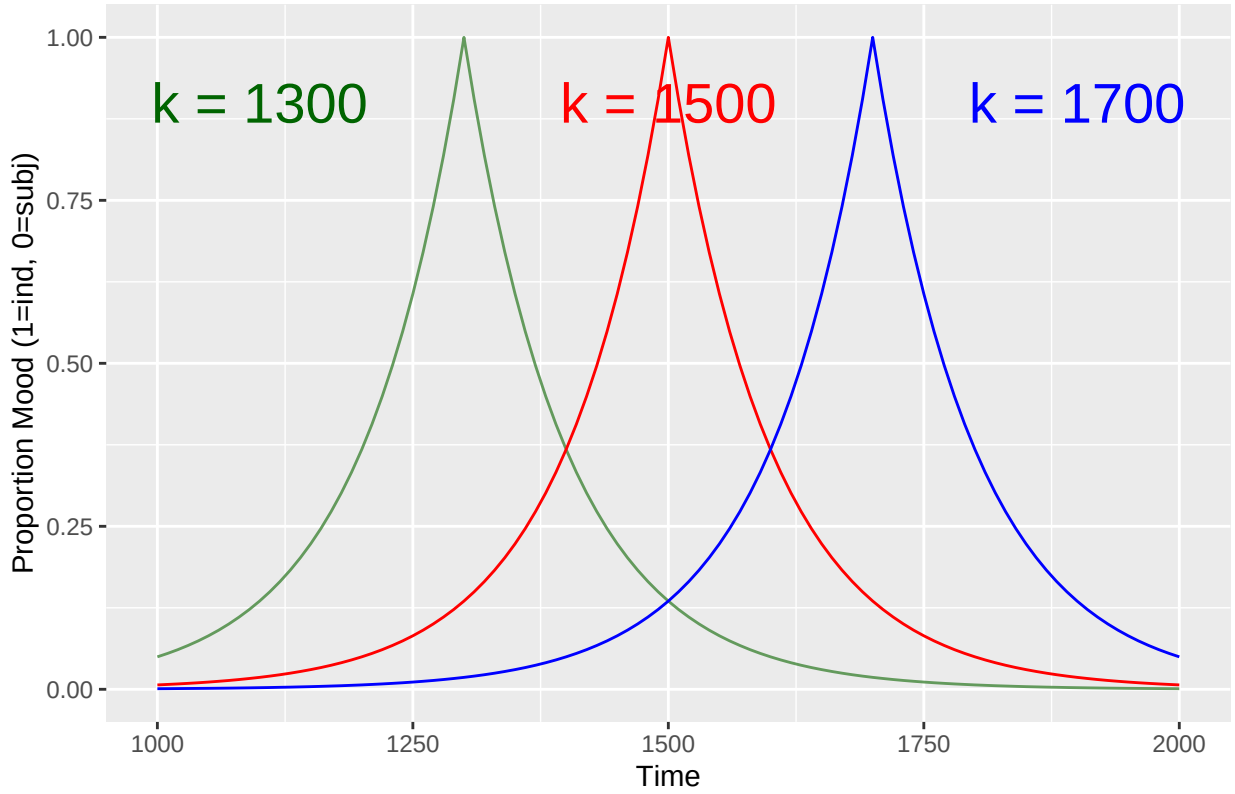
```
                  ylim(0,1)+
                 xlim(1000,2000)+
                annotate("text", x = 1700, y = 0.9,
                         label = "m = 1",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="darkgreen"
                         )+
               annotate("text", x = 1700, y = 0.8,
                         label = "m = 0.7",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="red"
                        )+
              annotate("text", x = 1700, y = 0.7,
                         label = "m = 0.4",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="blue"
                        )
```

```
plot.laplace1
```



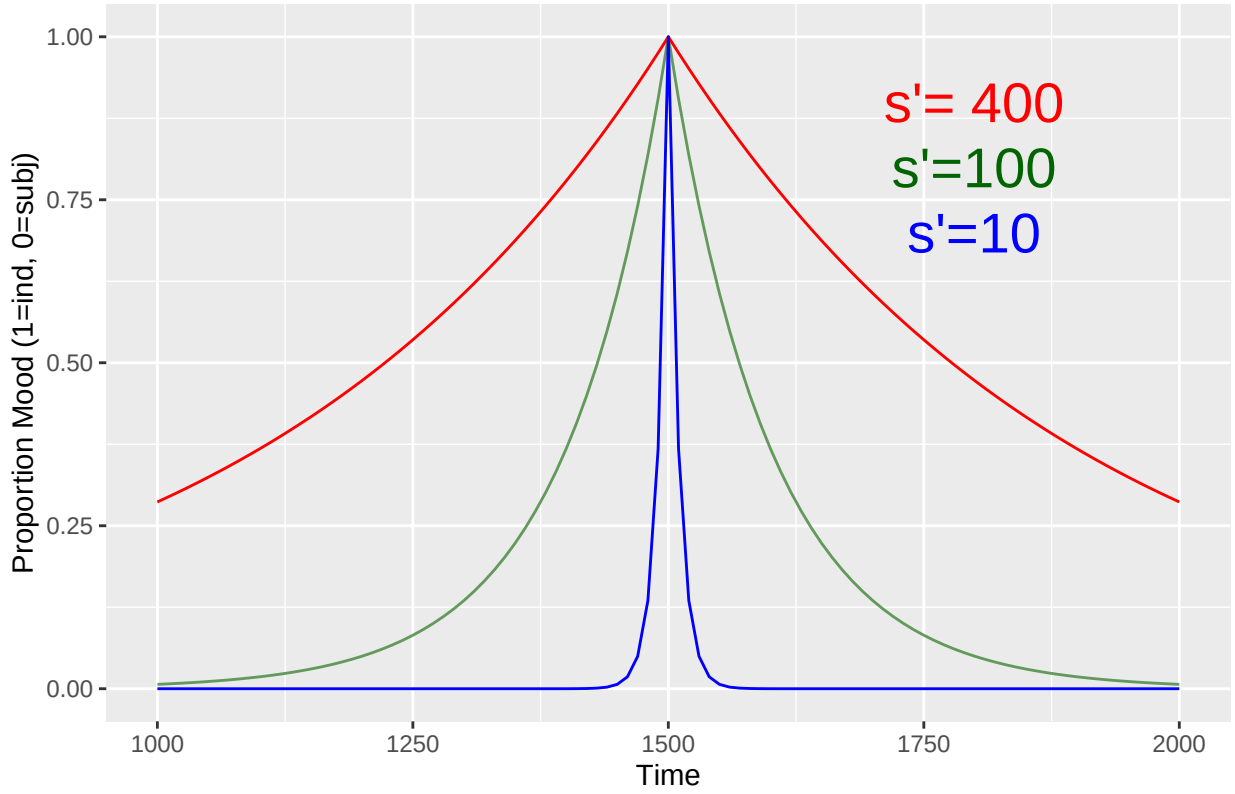

```
# The t0 parameter:
```

```
laplace4 <- function(x){1*exp(-abs(x-1300)/100)}
laplace5 <- function(x){1*exp(-abs(x-1500)/100)}
laplace6 <- function(x){1*exp(-abs(x-1700)/100)}

plot.laplace2 <- ggplot()+
                  geom_function(fun=laplace4, color = "#4c8c44d9")+
                  geom_function(fun=laplace5, color = "red")+
                 geom_function(fun=laplace6, color = "blue")+
                  labs(title="",  # axis
                       x = "Time",
                       y="Proportion Mood (1=ind, 0=subj)")+
                   ylim(0,1)+
                  xlim(1000,2000)+
                 annotate("text", x = 1100, y = 0.9,
                          label = "k = 1300",
                          family= theme_get()$text[["family"]],
                           size= theme_get()$text[["size"]]/1.5,
                          color="darkgreen"
                          )+
               annotate("text", x = 1500, y = 0.9,
                          label = "k = 1500",
                          family= theme_get()$text[["family"]],
                           size= theme_get()$text[["size"]]/1.5,
                          color="red"
                         )+
              annotate("text", x = 1900, y = 0.9,
                          label = "k = 1700",
                          family= theme_get()$text[["family"]],
                           size= theme_get()$text[["size"]]/1.5,
                          color="blue"
                         )


plot.laplace2
```




```
## S' parameter:

laplace7 <- function(x){1*exp(-abs(x-1500)/100)}
laplace8 <- function(x){1*exp(-abs(x-1500)/400)}
laplace9 <- function(x){1*exp(-abs(x-1500)/10)}

plot.laplace3 <- ggplot()+
                 geom_function(fun=laplace7, color = "#4c8c44d9")+
                 geom_function(fun=laplace8, color = "red")+
                geom_function(fun=laplace9, color = "blue")+
                 labs(title="",  # axis
                      x = "Time",
                      y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                 xlim(1000,2000)+
                annotate("text", x = 1800, y = 0.8,
                         label = "s'=100",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="darkgreen"
                         )+
               annotate("text", x = 1800, y = 0.9,
                         label = "s'= 400",
                         family= theme_get()$text[["family"]],
                          size= theme_get()$text[["size"]]/1.5,
                         color="red"
```

```
                    )+
          annotate("text", x = 1800, y = 0.7,
                    label = "s'=10",
                    family= theme_get()$text[["family"]],
                     size= theme_get()$text[["size"]]/1.5,
                    color="blue"
                    )


plot.laplace3
```



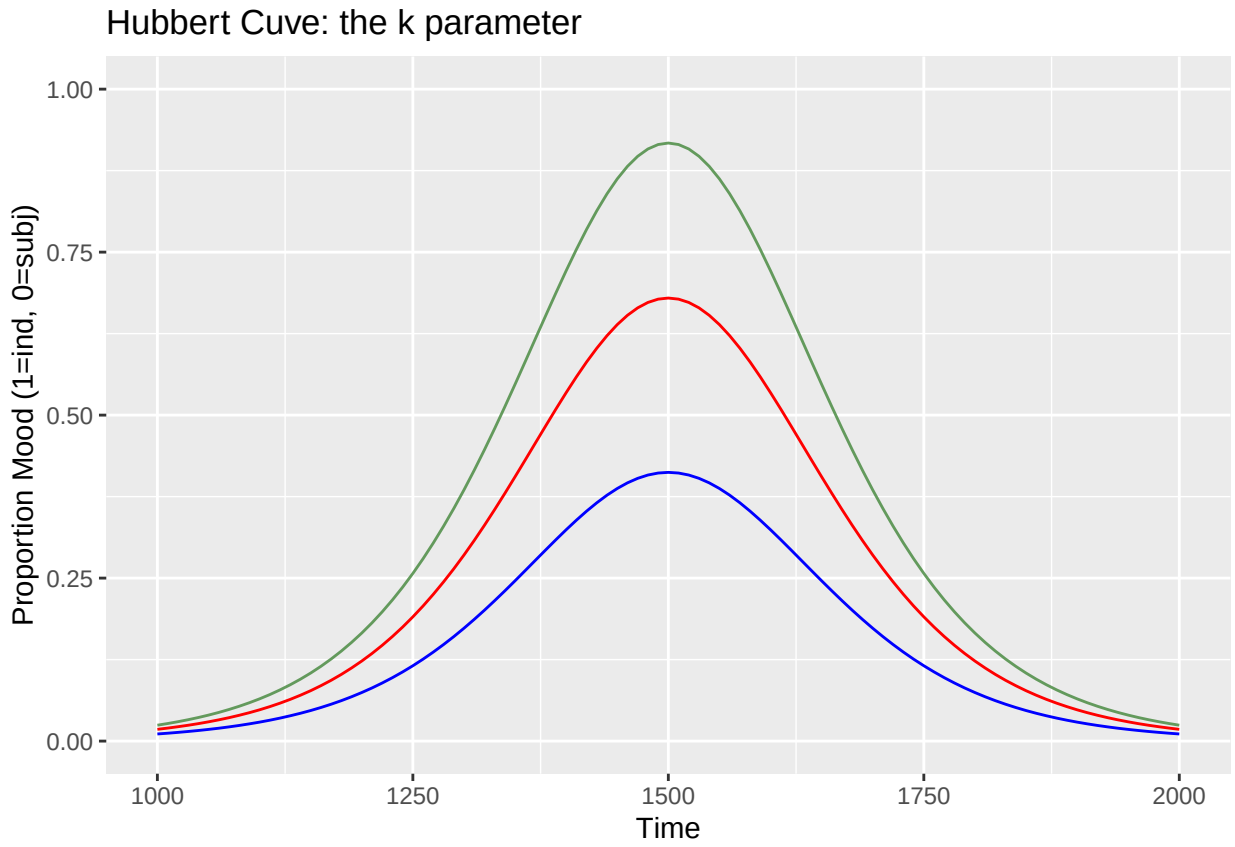

```
#combining the plots:
combined.laplace <- ggarrange(plot.laplace3,plot.laplace2,plot.laplace1, ncol = 3)
```

```
ggsave(combined.laplace, file="laplace-parameters.png", width = 16, height = 5)
```

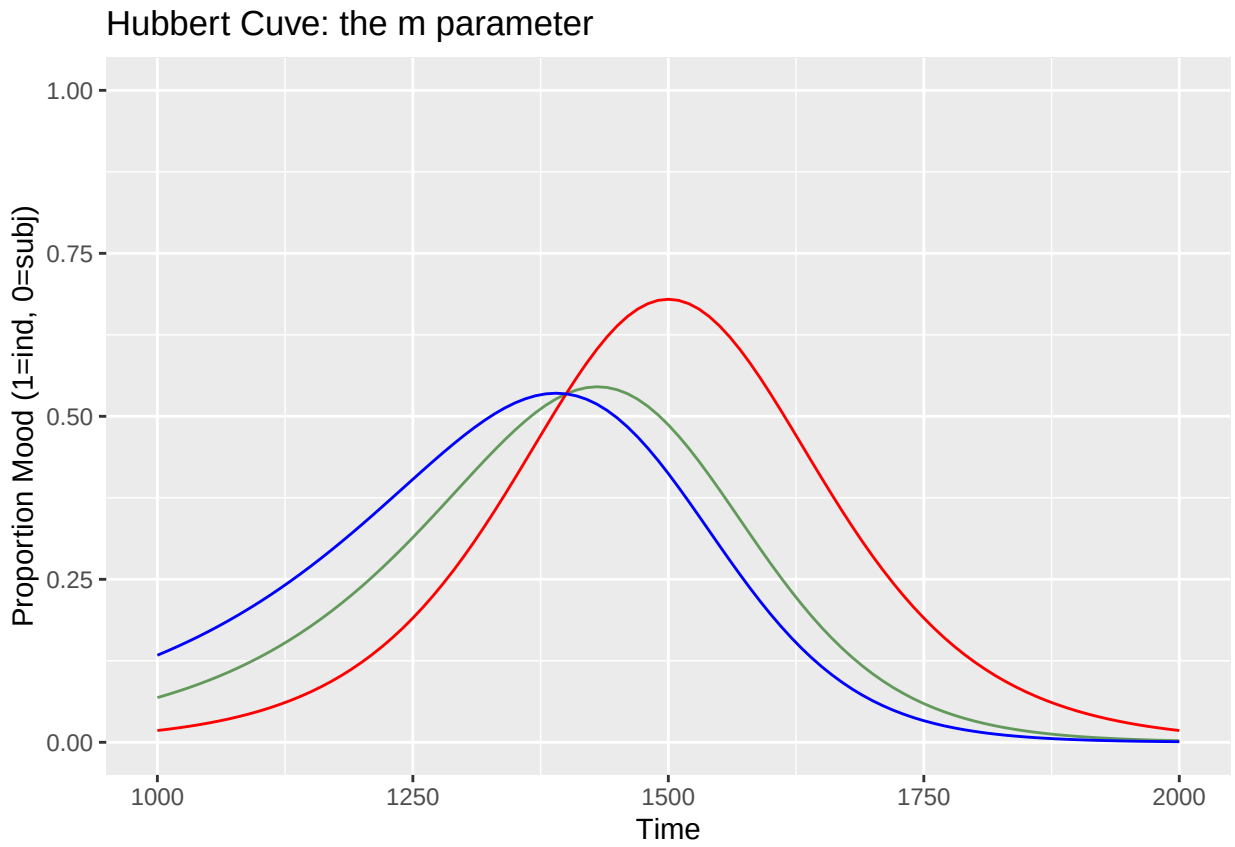
5. Hubbert Curve

```
hubbert1 <- function(x){(exp(-(x-1370)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert2 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert3 <- function(x){(exp(-(x-1450)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}

plot.hubbert1 <- ggplot()+
                  geom_function(fun=hubbert1, color = "#4c8c44d9")+
                  geom_function(fun=hubbert2, color = "red")+
                 geom_function(fun=hubbert3, color = "blue")+
```

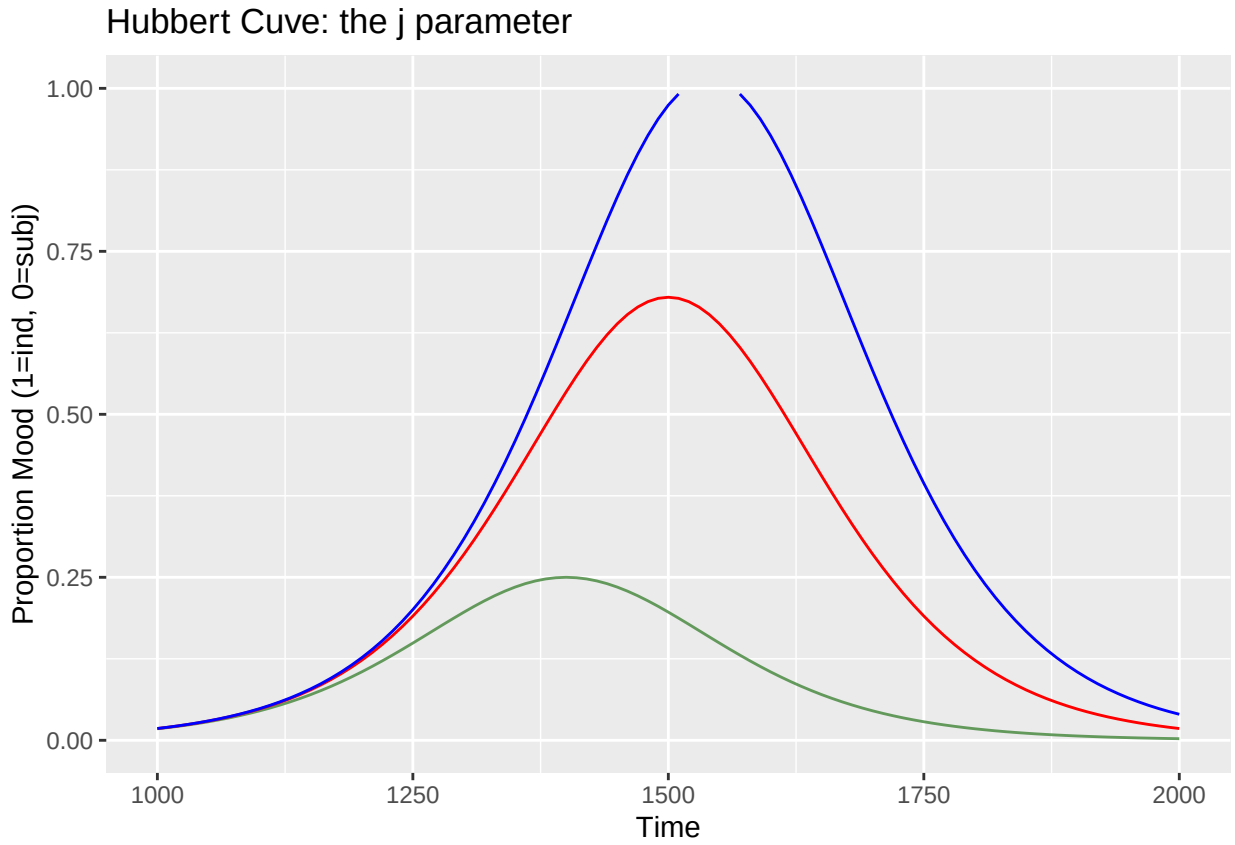
```
                labs(title="Hubbert Cuve: the k parameter",  # axis
                     x = "Time",
                     y="Proportion Mood (1=ind, 0=subj)")+
                 ylim(0,1)+
                xlim(1000,2000)

plot.hubbert1
```



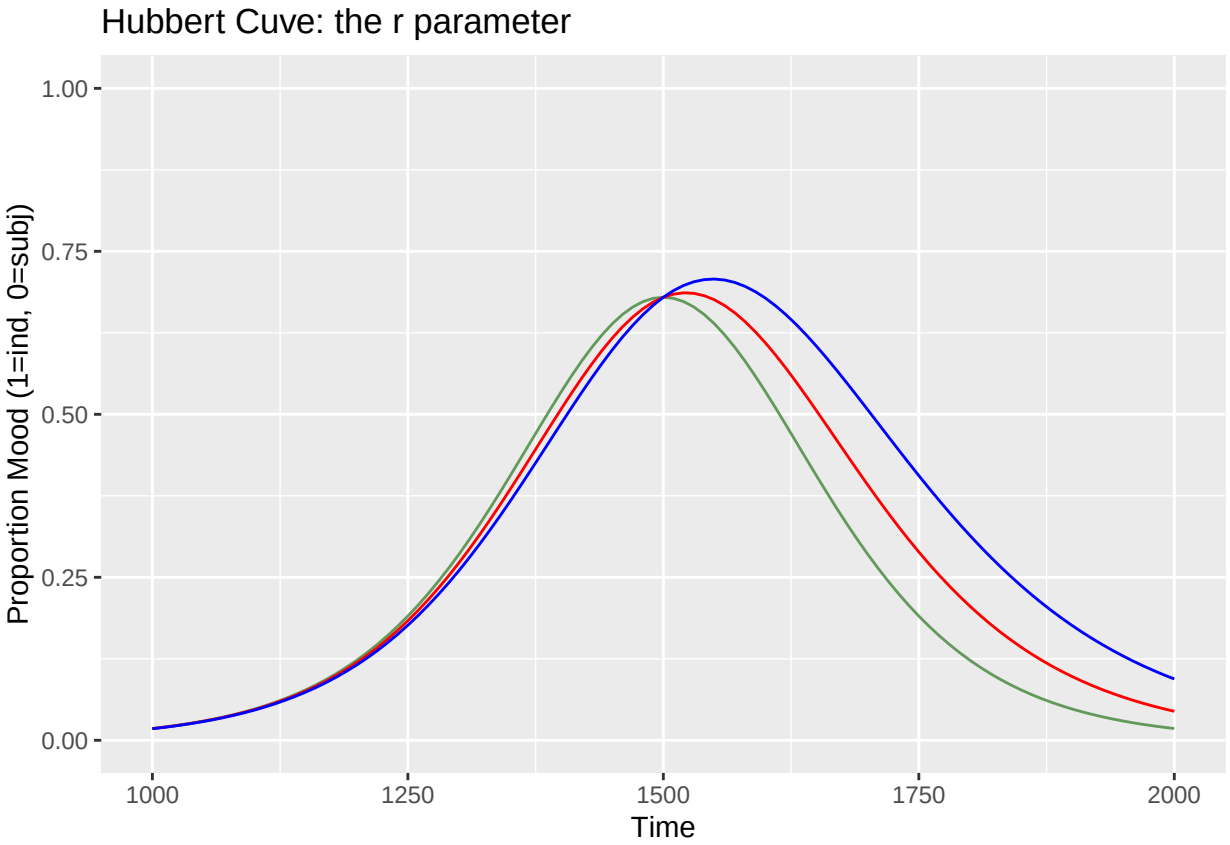

```
hubbert4 <- function(x){(exp(-(x-1400)/(-150)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert5 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert6 <- function(x){(exp(-(x-1400)/(-200)))/(1+exp(-(x-1500)/(-100)))^2}

plot.hubbert2 <- ggplot()+
                 geom_function(fun=hubbert4, color = "#4c8c44d9")+
                 geom_function(fun=hubbert5, color = "red")+
                geom_function(fun=hubbert6, color = "blue")+
                 labs(title="Hubbert Cuve: the m parameter",  # axis
                      x = "Time",
                      y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                 xlim(1000,2000)

plot.hubbert2
```




```
hubbert7 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1400)/(-100)))^2}
hubbert8 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert9 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1540)/(-100)))^2}

plot.hubbert3 <- ggplot()+
                 geom_function(fun=hubbert7, color = "#4c8c44d9")+
                 geom_function(fun=hubbert8, color = "red")+
                geom_function(fun=hubbert9, color = "blue")+
                 labs(title="Hubbert Cuve: the j parameter",  # axis
                      x = "Time",
                      y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                 xlim(1000,2000)

plot.hubbert3
```




```
hubbert10 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-100)))^2}
hubbert11 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-110)))^2}
hubbert12 <- function(x){(exp(-(x-1400)/(-100)))/(1+exp(-(x-1500)/(-120)))^2}

plot.hubbert4 <- ggplot()+
                 geom_function(fun=hubbert10, color = "#4c8c44d9")+
                 geom_function(fun=hubbert11, color = "red")+
                geom_function(fun=hubbert12, color = "blue")+
                 labs(title="Hubbert Cuve: the r parameter",  # axis
                      x = "Time",
                      y="Proportion Mood (1=ind, 0=subj)")+
                  ylim(0,1)+
                 xlim(1000,2000)

plot.hubbert4
```


Hubbert Cuve: the r parameter
Proportion Mood (1=ind, 0=subj)
1.00
0.75
0.50
0.25
0.00
1000
1250
1500
1750
2000
Time