

# Replications of RQ2-4

## Data preparation

We load the file with the scores from LIWC and rescale them in the range [1,5].

```
personality = read_delim(params$data, ";", escape_double = FALSE)
personality$openness <- resca(personality,openness,
                             new_min=1, new_max=5)$openness_res
personality$conscientiousness <- resca(personality,conscientiousness,
                                       new_min=1, new_max=5)$conscientiousness_res
personality$extraversion <- resca(personality,extraversion,
                                  new_min=1, new_max=5)$extraversion_res
personality$agreeableness <- resca(personality,agreeableness,
                                   new_min=1, new_max=5)$agreeableness_res
personality$neuroticism <- resca(personality,neuroticism,
                                new_min=1, new_max=5)$neuroticism_res
```

Now we load the commit data and merge them with the personality data.

```
commit = read_delim(params$commits, ";", escape_double = FALSE)

# Find which developers appear in the intersection of the two data sets
both = intersect(unique(commit$uid), unique(personality$uid))

# Extract data only for the intersection developers
# (filter out people with 0 commits)
commit.both = subset(commit, uid %in% both &
                    num_authored_commits > 0)

# Count total number of projects and total number of commits across all projects, per person
commit.count = sqldf("select uid,
                        sum(num_authored_commits) as 'total_commits',
                        count(project) as 'total_projects',
                        max(last_authored_datetime) as last_authored_datetime,
                        min(first_integrated_datetime) as first_integrated_datetime
                        from `commit.both` group by uid")

# Filter out people who are still active (have at least one commit
# during the last 3 months before data collection). We can't know
# if they will remain one-time contributors or have more commits
commit.count = subset(commit.count, last_authored_datetime < as.POSIXct("2017-09-01 20:18:02"))

# Identify people with only one commit total, across all projects.
# These are the one-timers. The others are more active, even if they
# have projects with only one commit
one.timers = subset(commit.count, total_commits == 1)$uid
multi.timers = subset(commit.count, total_commits > 1)$uid
one.or.multi.timers = subset(commit.count, total_commits >= 1)$uid

# Assign a binary label "one_timer" to everyone in the personality
```

```

# data, based on the distinction above
p = subset(personality, uid %in% one.timers | uid %in% multi.timers)
p$one_timer = FALSE
for (i in 1:nrow(p)){
  p[i,]$one_timer = p[i,]$uid %in% one.timers
}

# Compute average personality scores per person, across time and across all projects
# We will use this simple data in the analysis below, because personality doesn't
# change much (see boxplots)
p.aggr = sqldf("select uid, avg(openness) as 'openness',
               avg(agreeableness) as 'agreeableness',
               avg(neuroticism) as 'neuroticism',
               avg(extraversion) as 'extraversion',
               avg(conscientiousness) as 'conscientiousness',
               sum(word_count) as word_count
               from p group by uid")

# Apply the "one_timer" binary label to this aggregate data set
p.aggr$one_timer = FALSE
for (i in 1:nrow(p.aggr)){
  p.aggr[i,]$one_timer = p.aggr[i,]$uid %in% one.timers
}

# Apply the "multi_timer" binary label to this aggregate data set
p.aggr$m_timer = FALSE
for (i in 1:nrow(p.aggr)){
  p.aggr[i,]$m_timer = p.aggr[i,]$uid %in% multi.timers
}

```

## RQ2 Personality of core vs. peripheral developers

We perform a series of Wilcoxon Mann Whitney for unpaired groups, one for each trait. We adjust the significance with Bonferroni due to multiple comparisons. The differences are not significant (adjusted p-values all > 0.05).

```

integrations = subset(commit, uid %in% both & num_integrated_commits > 0)
integration.count = sqldf("select uid,
                           min(first_integrated_datetime) as first_integrated_datetime,
                           max(last_integrated_datetime) as last_integrated_datetime,
                           num_integrated_commits
                           from `integrations` group by uid")
integration.count = subset(integration.count, last_integrated_datetime < as.POSIXct("2017-09-01 20:18:00"))
integrators = subset(integration.count, num_integrated_commits >= 1)$uid

# peripheral
authors_non_integrators = unique(commit.both[!commit.both$uid %in% integrators, ]$uid)
c_b_n_i = Reduce(intersect, list(commit.both$uid, authors_non_integrators))
peripheral = personality[personality$uid %in% c_b_n_i, ]
peripheral = sqldf::sqldf("select uid,
                           avg(openness) as openness,
                           avg(conscientiousness) as conscientiousness,
                           avg(extraversion) as extraversion,
                           avg(agreeableness) as agreeableness,
                           avg(neuroticism) as neuroticism

```

```

                                from peripheral
                                group by uid")
# core
c_b_i = Reduce(intersect, list(commit.both$uid, integrators))
core = personality[personality$uid %in% c_b_i, ]
core = sqldf::sqldf("select uid,
                    avg(openness) as openness,
                    avg(conscientiousness) as conscientiousness,
                    avg(extraversion) as extraversion,
                    avg(agreeableness) as agreeableness,
                    avg(neuroticism) as neuroticism
                    from core
                    group by uid")

print("*****")

## [1] "*****"
print("          openness          ")

## [1] "          openness          "
print("*****")

## [1] "*****"
wto = wilcox.test(peripheral$openness, core$openness, conf.int=TRUE, paired=FALSE)
cliff.delta(peripheral$openness, core$openness, return.dm=TRUE)

##
## Cliff's Delta
##
## delta estimate: 0.173 (small)
## 95 percent confidence interval:
##   lower   upper
## -0.0333  0.3648
print("*****")

## [1] "*****"
print("      conscientiousness      ")

## [1] "      conscientiousness      "
print("*****")

## [1] "*****"
wtc = wilcox.test(peripheral$conscientiousness, core$conscientiousness, conf.int=TRUE, paired=FALSE)
cliff.delta(peripheral$conscientiousness, core$conscientiousness, return.dm=TRUE)

##
## Cliff's Delta
##
## delta estimate: 0.0446 (negligible)
## 95 percent confidence interval:
##   lower   upper
## -0.160  0.245

```

```

print("*****")

## [1] "*****"
print("      extraversion      ")

## [1] "      extraversion      "
print("*****")

## [1] "*****"
wte = wilcox.test(peripheral$extraversion, core$extraversion, conf.int=TRUE, paired=FALSE)
cliff.delta(peripheral$extraversion, core$extraversion, return.dm=TRUE)

##
## Cliff's Delta
##
## delta estimate: -0.00105 (negligible)
## 95 percent confidence interval:
## lower upper
## -0.204  0.202
print("*****")

## [1] "*****"
print("      agreeableness      ")

## [1] "      agreeableness      "
print("*****")

## [1] "*****"
wta = wilcox.test(peripheral$agreeableness, core$agreeableness, conf.int=TRUE, paired=FALSE)
cliff.delta(peripheral$agreeableness, core$agreeableness, return.dm=TRUE)

##
## Cliff's Delta
##
## delta estimate: -0.115 (negligible)
## 95 percent confidence interval:
## lower upper
## -0.3104  0.0897
print("*****")

## [1] "*****"
print("      neuroticism      ")

## [1] "      neuroticism      "
print("*****")

## [1] "*****"
wtn = wilcox.test(peripheral$neuroticism, core$neuroticism, conf.int=TRUE, paired=FALSE)
cliff.delta(peripheral$neuroticism, core$neuroticism, return.dm=TRUE)

##

```

```
## Cliff's Delta
##
## delta estimate: -0.0804 (negligible)
## 95 percent confidence interval:
## lower upper
## -0.279 0.125

print("Bonferroni")

## [1] "Bonferroni"

p.adjust(c(wto$p.value, wtc$p.value, wte$p.value, wta$p.value, wtn$p.value), method = "bonferroni")

## [1] 0.495 1.000 1.000 1.000 1.000
```

## RQ3 Individual personality differences before and after becoming a project contributor

We use a series Wilcoxon Signed-Rank test for paired samples (before and after), repeated for each of the five traits. All the test returns differences that are not statistically significant after Bonferroni corrections for multiple comparisons, as can also be observed from the box plots below.

```
df = data.frame(when=character(0), value=integer(0), stringsAsFactors = FALSE)

for (i in 1:length(integrators)){
  split_index = as.Date(integration.count[integration.count$uid == integrators[i], ]$first_integrated_date)
  p_tot = personality[personality$uid == integrators[i],]
  p_prev = personality[personality$uid == integrators[i] & as.yearmon(personality$month) < as.yearmon(split_index)]
  p_aft = personality[personality$uid == integrators[i] & as.yearmon(personality$month) >= as.yearmon(split_index)]

  df[nrow(df)+1, ] = list("O before", mean(p_prev$openness))
  df[nrow(df)+1, ] = list("O after", mean(p_aft$openness))
  df[nrow(df)+1, ] = list("C before", mean(p_prev$conscientiousness))
  df[nrow(df)+1, ] = list("C after", mean(p_aft$conscientiousness))
  df[nrow(df)+1, ] = list("E before", mean(p_prev$extraversion))
  df[nrow(df)+1, ] = list("E after", mean(p_aft$extraversion))
  df[nrow(df)+1, ] = list("A before", mean(p_prev$agreeableness))
  df[nrow(df)+1, ] = list("A after", mean(p_aft$agreeableness))
  df[nrow(df)+1, ] = list("N before", mean(p_prev$neuroticism))
  df[nrow(df)+1, ] = list("N after", mean(p_aft$neuroticism))
}

df_o = df[df$when=="O before" | df$when=="O after", ]
df_o$when <- factor(df_o$when, levels = c("O before", "O after") )
ob = wilcox.test(df[df$when=="O before", ]$value, df[df$when=="O after", ]$value, correct = FALSE, paired = TRUE)

df_c = df[df$when=="C before" | df$when=="C after", ]
df_c$when <- factor(df_c$when, levels = c("C before", "C after") )
cb = wilcox.test(df[df$when=="C before", ]$value, df[df$when=="C after", ]$value, correct = FALSE, paired = TRUE)

df_e = df[df$when=="E before" | df$when=="E after", ]
df_e$when <- factor(df_e$when, levels = c("E before", "E after") )
eb = wilcox.test(df[df$when=="E before", ]$value, df[df$when=="E after", ]$value, correct = FALSE, paired = TRUE)
```

```

df_a = df[df$when=="A before" | df$when=="A after", ]
df_a$when <- factor(df_a$when, levels = c("A before", "A after") )
ab=wilcox.test(df[df$when=="A before", ]$value, df[df$when=="A after", ]$value, correct = FALSE, paired = FALSE)

df_n = df[df$when=="N before" | df$when=="N after", ]
df_n$when <- factor(df_n$when, levels = c("N before", "N after") )
nb = wilcox.test(df[df$when=="N before", ]$value, df[df$when=="N after", ]$value, correct = FALSE, paired = FALSE)

bplot_o <- ggplot(df_o, aes(x = when, y = value)) +
  geom_boxplot(colour = "black", fill = "white",
    size = 0.4, notch = TRUE) +
  scale_y_continuous(name = "Personality trait score",
    limits=c(1, 5)) +
  scale_x_discrete(name = "") +
  ggtitle("Openness") +
  theme_bw() +
  stat_boxplot(geom = "errorbar", width = 0.3) +
  theme(panel.grid.major = element_blank(),
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    text=element_text(),
    axis.title = element_text(face="bold"),
    axis.text.x=element_text(colour="black", size = 11),
    axis.text.y=element_text(colour="black", size = 9),
    axis.line = element_line(size=0.5, colour = "black"))

bplot_c <-ggplot(df_c, aes(x = when, y = value)) +
  geom_boxplot(colour = "black", fill = "white",
    size = 0.4, notch = TRUE) +
  scale_y_continuous(name = "",
    limits=c(1, 5)) +
  scale_x_discrete(name = "") +
  ggtitle("Conscientious.") +
  theme_bw() +
  stat_boxplot(geom = "errorbar", width = 0.3) +
  theme(panel.grid.major = element_blank(),
    plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
    text=element_text(),
    axis.title = element_text(face="bold"),
    axis.text.x=element_text(colour="black", size = 11),
    axis.text.y=element_text(colour="black", size = 9),
    axis.line = element_line(size=0.5, colour = "black"))

bplot_e <-ggplot(df_e, aes(x = when, y = value)) +
  geom_boxplot(colour = "black", fill = "white",
    size = 0.4, notch = TRUE) +
  scale_y_continuous(name = "",
    #breaks = seq(0, 1, 25),
    limits=c(1, 5)) +
  scale_x_discrete(name = "") +
  ggtitle("Extraversion") +
  theme_bw() +

```

```

stat_boxplot(geom = "errorbar", width = 0.3) +
theme(panel.grid.major = element_blank(),
      plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
      text=element_text(),
      axis.title = element_text(face="bold"),
      axis.text.x=element_text(colour="black", size = 11),
      axis.text.y=element_text(colour="black", size = 9),
      axis.line = element_line(size=0.5, colour = "black"))

bplot_a <-ggplot(df_a, aes(x = when, y = value)) +
  geom_boxplot(colour = "black", fill = "white",
              size = 0.4, notch = TRUE) +
  scale_y_continuous(name = "Personality trait score",
                    #breaks = seq(0, 1, 25),
                    limits=c(1, 5)) +
  scale_x_discrete(name = "") +
  ggtitle("Agreeableness") +
  theme_bw() +
  stat_boxplot(geom = "errorbar", width = 0.3) +
  theme(panel.grid.major = element_blank(),
        plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
        text=element_text(),
        axis.title = element_text(face="bold"),
        axis.text.x=element_text(colour="black", size = 11),
        axis.text.y=element_text(colour="black", size = 9),
        axis.line = element_line(size=0.5, colour = "black"))

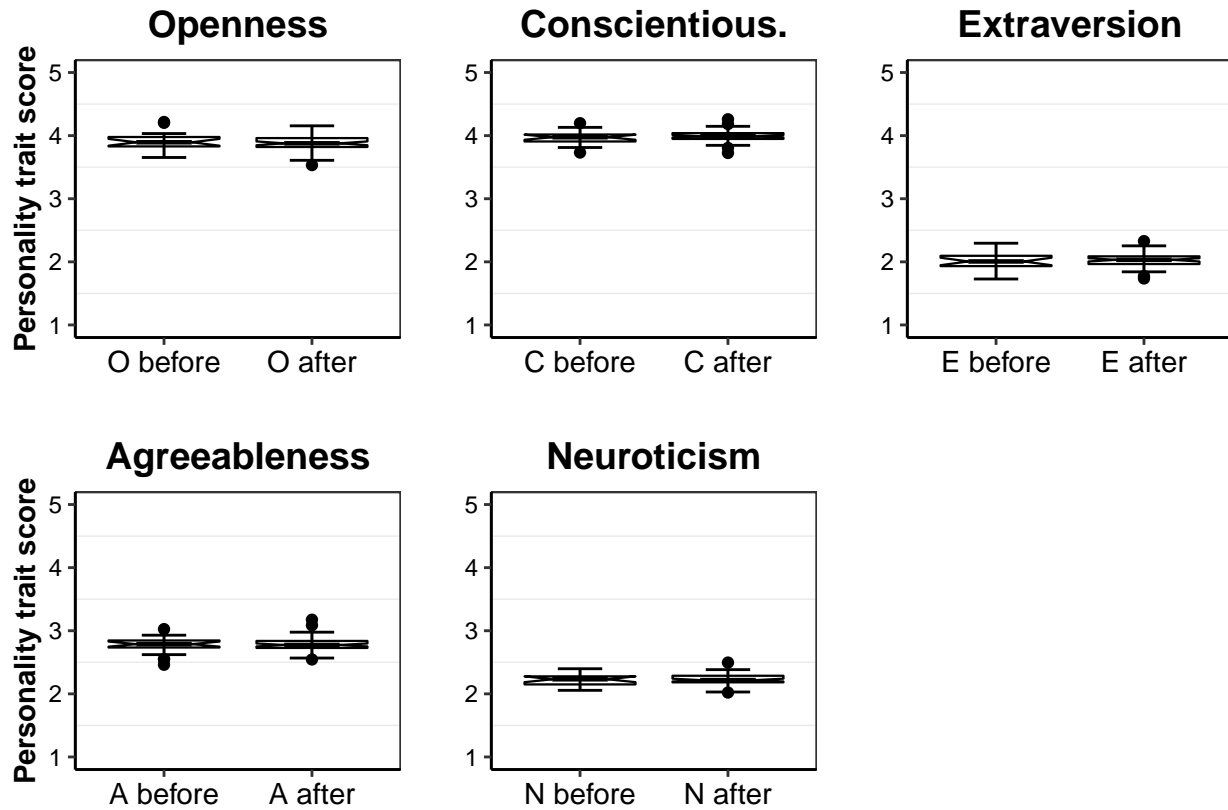
bplot_n <-ggplot(df_n, aes(x = when, y = value)) +
  geom_boxplot(colour = "black", fill = "white",
              size = 0.4, notch = TRUE) +
  scale_y_continuous(name = "",
                    limits=c(1, 5)) +
  scale_x_discrete(name = "") +
  ggtitle("Neuroticism") +
  theme_bw() +
  stat_boxplot(geom = "errorbar", width = 0.3) +
  theme(panel.grid.major = element_blank(),
        plot.title = element_text(size = 14, face = "bold", hjust = 0.5),
        text=element_text(),
        axis.title = element_text(face="bold"),
        axis.text.x=element_text(colour="black", size = 11),
        axis.text.y=element_text(colour="black", size = 9),
        axis.line = element_line(size=0.5, colour = "black"))

p.adjust(c(ob$p.value, cb$p.value, eb$p.value, ab$p.value, nb$p.value), method = "bonferroni")

## [1] 1.000 0.765 1.000 1.000 1.000

grid.arrange(bplot_o, bplot_c, bplot_e, bplot_a, bplot_n, ncol = 3, nrow=2)

```



#### RQ4 — variation with the degree of development activity

Starting from the core and peripheral groups of developers of RQ2, we further split the groups into high vs. low contributors. We then perform the unpaired comparisons of the median personality scores between these high vs. low-activity developers within the core and peripheral groups. Results are shown in the table below. The Wilcoxon Rank Sum tests reveal no cases of statistically significant differences between the pairs of trait distributions (i.e., adjusted p-values > 0.05 after Bonferroni correction).

```
csbo = sqldf::sqldf("select uid,
                      sum(num_authored_commits) as num_authored_commits,
                      sum(num_integrated_commits) as num_integrated_commits
                      from `commit.both`
                      group by uid")
# split peripheral in low vs higher commit authors around the mean
Mp = floor(mean(csbo$num_authored_commits))
peripheral_low = fn$sqldf("select *
                          from peripheral left join csbo on peripheral.uid = csbo.uid
                          where num_authored_commits <= $Mp")
peripheral_high = fn$sqldf("select *
                          from peripheral left join csbo on peripheral.uid = csbo.uid
                          where num_authored_commits > $Mp")

wtc_hlpo = wilcox.test(peripheral_high$openness, peripheral_low$openness, conf.int=TRUE, paired=FALSE)
#cliff.delta(peripheral_high$openness, peripheral_low$openness, return.dm=TRUE)

wtc_hlpc = wilcox.test(peripheral_high$conscientiousness, peripheral_low$conscientiousness, conf.int=TRUE, paired=FALSE)
#cliff.delta(peripheral_high$conscientiousness, peripheral_low$conscientiousness, return.dm=TRUE)
```



```

wtc_hlpe = wilcox.test(peripheral_high$extraversion, peripheral_low$extraversion, conf.int=TRUE, paired=FALSE)
#cliff.delta(peripheral_high$extraversion, peripheral_low$extraversion, return.dm=TRUE)

wtc_hlpa = wilcox.test(peripheral_high$agreeableness, peripheral_low$agreeableness, conf.int=TRUE, paired=FALSE)
#cliff.delta(peripheral_high$agreeableness, peripheral_low$agreeableness, return.dm=TRUE)

wtc_hlpn = wilcox.test(peripheral_high$neuroticism, peripheral_low$neuroticism, conf.int=TRUE, paired=FALSE)
#cliff.delta(peripheral_high$neuroticism, peripheral_low$neuroticism, return.dm=TRUE)

adj_p <- p.adjust(c(wtc_hlpo$p.value, wtc_hlpc$p.value, wtc_hlpe$p.value, wtc_hlpa$p.value, wtc_hlpn$p.value))

df <- data.frame(matrix(ncol = 5, nrow = 12))
x <- c("Trait", "W", "p-value", "CI 95% low", "CI 95% high")
colnames(df) <- x
df[1,] <- c("High vs. low commit authors (peripheral)", "", "", "", "")
df[2,] <- c("openness", as.numeric(wtc_hlpo$statistic), adj_p[1], round(as.numeric(wtc_hlpo$conf.int), 2), round(as.numeric(wtc_hlpo$conf.int), 2))
df[3,] <- c("conscientiousness", as.numeric(wtc_hlpc$statistic), adj_p[2], round(as.numeric(wtc_hlpc$conf.int), 2), round(as.numeric(wtc_hlpc$conf.int), 2))
df[4,] <- c("extraversion", as.numeric(wtc_hlpo$statistic), adj_p[3], round(as.numeric(wtc_hlpe$conf.int), 2), round(as.numeric(wtc_hlpe$conf.int), 2))
df[5,] <- c("agreeableness", as.numeric(wtc_hlpa$statistic), adj_p[4], round(as.numeric(wtc_hlpa$conf.int), 2), round(as.numeric(wtc_hlpa$conf.int), 2))
df[6,] <- c("neuroticism", as.numeric(wtc_hlpn$statistic), adj_p[5], round(as.numeric(wtc_hlpn$conf.int), 2), round(as.numeric(wtc_hlpn$conf.int), 2))

# split core in low vs higher commit integrators around the mean
Mc = ceiling(mean(csbo$num_integrated_commits))
core_low = fn$sqldf("select *
                    from core left join csbo on core.uid = csbo.uid
                    where num_authored_commits <= $Mc")
core_high = fn$sqldf("select *
                    from core left join csbo on core.uid = csbo.uid
                    where num_authored_commits > $Mc")

wtc_hlco = wilcox.test(core_high$openness, core_low$openness, conf.int=TRUE, paired=FALSE)
#cliff.delta(core_high$openness, core_low$openness, return.dm=TRUE)

wtc_hlcc = wilcox.test(core_high$conscientiousness, core_low$conscientiousness, conf.int=TRUE, paired=FALSE)
#cliff.delta(core_high$conscientiousness, core_low$conscientiousness, return.dm=TRUE)

wtc_hlce = wilcox.test(core_high$extraversion, core_low$extraversion, conf.int=TRUE, paired=FALSE)
#cliff.delta(core_high$extraversion, core_low$extraversion, return.dm=TRUE)

wtc_hlca = wilcox.test(core_high$agreeableness, core_low$agreeableness, conf.int=TRUE, paired=FALSE)
#cliff.delta(core_high$agreeableness, core_low$agreeableness, return.dm=TRUE)

wtc_hlcn = wilcox.test(core_high$neuroticism, core_low$neuroticism, conf.int=TRUE, paired=FALSE)
#cliff.delta(core_high$neuroticism, core_low$neuroticism, return.dm=TRUE)

adj_p<-p.adjust(c(wtc_hlco$p.value, wtc_hlcc$p.value, wtc_hlce$p.value, wtc_hlca$p.value, wtc_hlcn$p.value))

df[7,] <- c("High vs. low commit authors (core)", "", "", "", "")
df[8,] <- c("openness", as.numeric(wtc_hlco$statistic), adj_p[1], round(as.numeric(wtc_hlco$conf.int), 2), round(as.numeric(wtc_hlco$conf.int), 2))
df[9,] <- c("conscientiousness", as.numeric(wtc_hlcc$statistic), adj_p[2], round(as.numeric(wtc_hlcc$conf.int), 2), round(as.numeric(wtc_hlcc$conf.int), 2))
df[10,] <- c("extraversion", as.numeric(wtc_hlce$statistic), adj_p[3], round(as.numeric(wtc_hlce$conf.int), 2), round(as.numeric(wtc_hlce$conf.int), 2))

```

```
df[11,] <- c("agreeableness", as.numeric(wtc_hlca$statistic), adj_p[4], round(as.numeric(wtc_hlca$conf.in
df[12,] <- c("neuroticism", as.numeric(wtc_hlcn$statistic), adj_p[5], round(as.numeric(wtc_hlcn$conf.in
df
```

##		Trait	W	p-value	CI 95% low	CI 95% high
## 1	High vs. low commit authors (peripheral)					
## 2		openness	520	1	-0.039	0.122
## 3		conscientiousness	557	1	-0.021	0.078
## 4		extraversion	520	1	-0.115	0.041
## 5		agreeableness	489	1	-0.078	0.1
## 6		neuroticism	389	1	-0.084	0.035
## 7	High vs. low commit authors (core)					
## 8		openness	165	1	-0.139	0.046
## 9		conscientiousness	253	1	-0.035	0.121
## 10		extraversion	242	1	-0.05	0.084
## 11		agreeableness	242	1	-0.052	0.102
## 12		neuroticism	183	1	-0.105	0.038