

forecast_timeseries_egjohnson

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```
# read in data as character
tcdat <- fread("app_data.csv", colClasses=c("character"))
tcdat %>% head
```

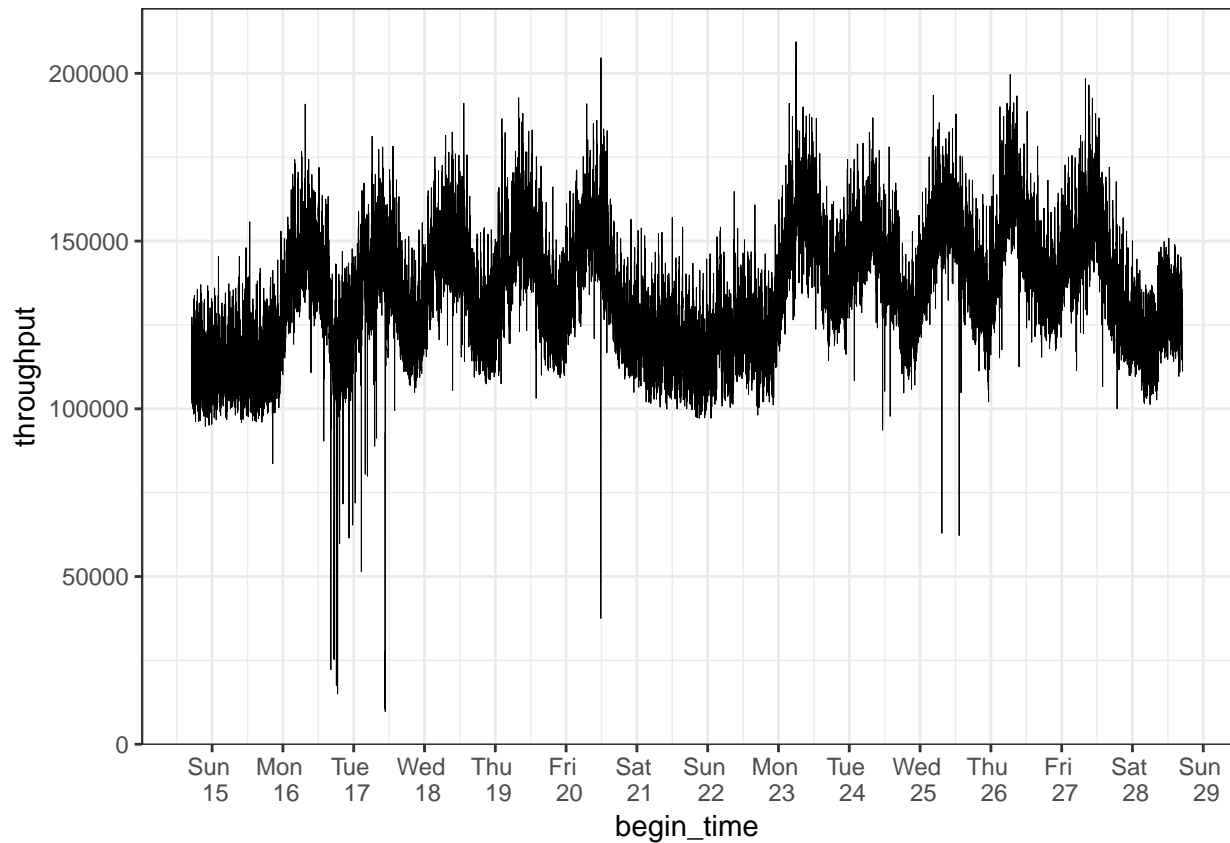
begin_time	average_response_time	throughput
1508025600	203.20011539812356	119586
1508025660	144.14319113189268	112493
1508025720	127.0975367190018	108595
1508025780	134.4365023956849	104563
1508025840	127.95972196725687	119842
1508025900	138.5803969580254	111901

```
#change UNIX timestamp to actual date
#seconds since Jan 01 1970. (UTC)
#convert characters to numeric
library(tidyr)
tcdat %>% dplyr::mutate(begin_time=anytime(as.integer(begin_time))) %>% dplyr::mutate_if(is.character, as.numeric)
tcdat %>% head
```

begin_time	average_response_time	throughput
2017-10-14 17:00:00	203.2001	119586
2017-10-14 17:01:00	144.1432	112493
2017-10-14 17:02:00	127.0975	108595
2017-10-14 17:03:00	134.4365	104563
2017-10-14 17:04:00	127.9597	119842
2017-10-14 17:05:00	138.5804	111901

Throughput peaks in the middle of the day - but only on weekdays

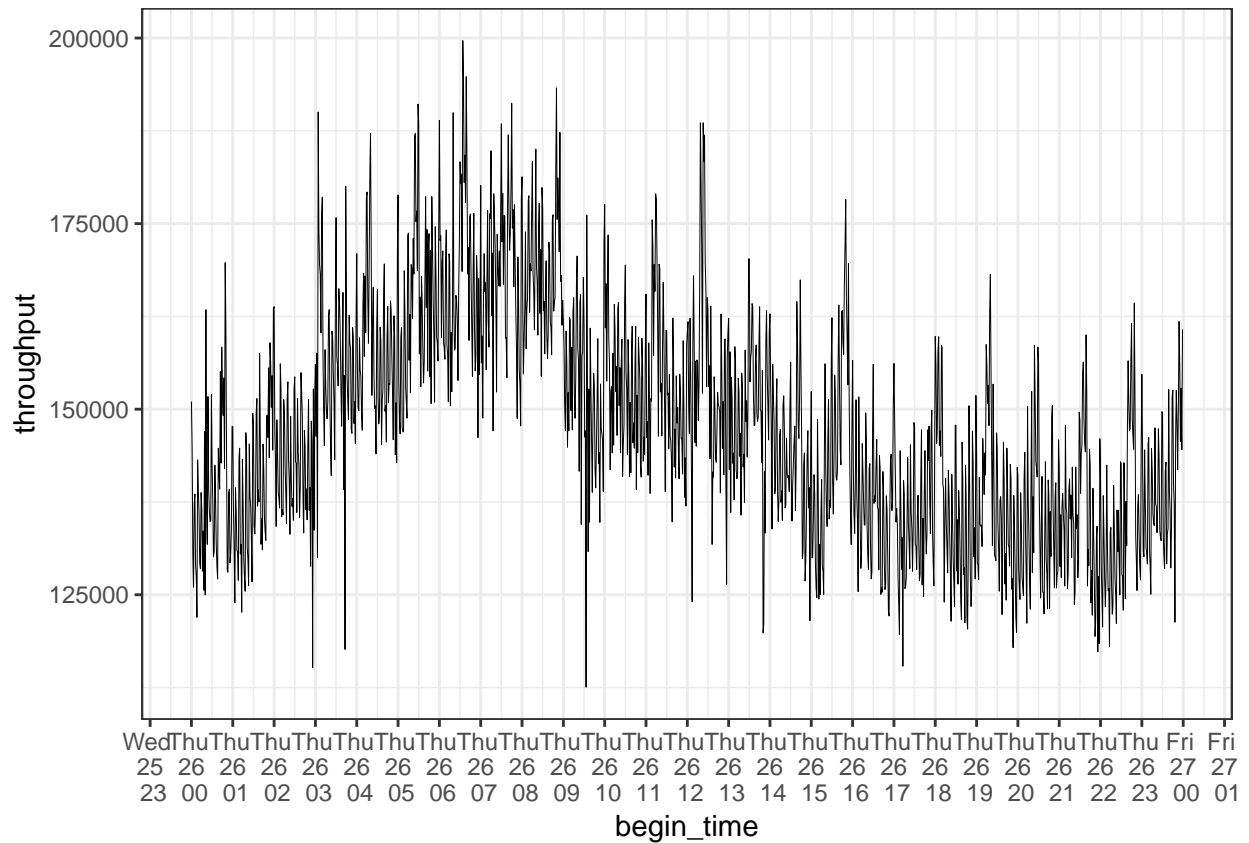
```
#labels = date_format("%a-%d\n%H:%M")
ggplot(tcdat, aes(x = begin_time, y = throughput)) +
  geom_line(size = 0.1) +
  scale_x_datetime(breaks = date_breaks("1 day"), labels=date_format("%a \n %d",tz=Sys.timezone()))+
  theme_bw()
```



On a weekday throughput typically peaks prior to noon then tapers off.

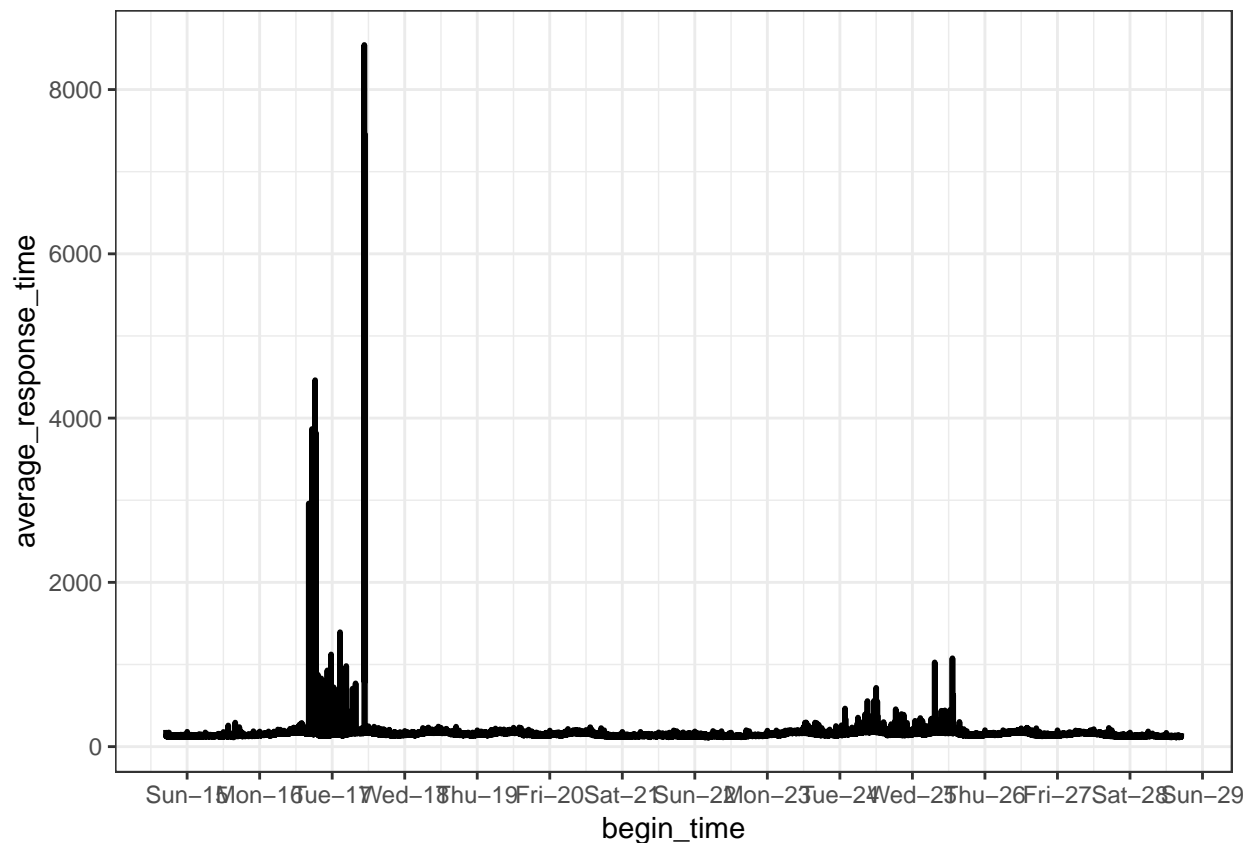
```
tcdat %>% dplyr::filter(day(begin_time) ==26)->tc.plot

ggplot(tc.plot, aes(x = begin_time, y = throughput)) +
  geom_line(size =0.1) +
  scale_x_datetime(breaks = date_breaks("1 hour"),labels=time_format("%a \n %d \n %H",tz=Sys.timezone()),
  theme_bw()
```



response time spikes on some weekdays with random random slow-downs

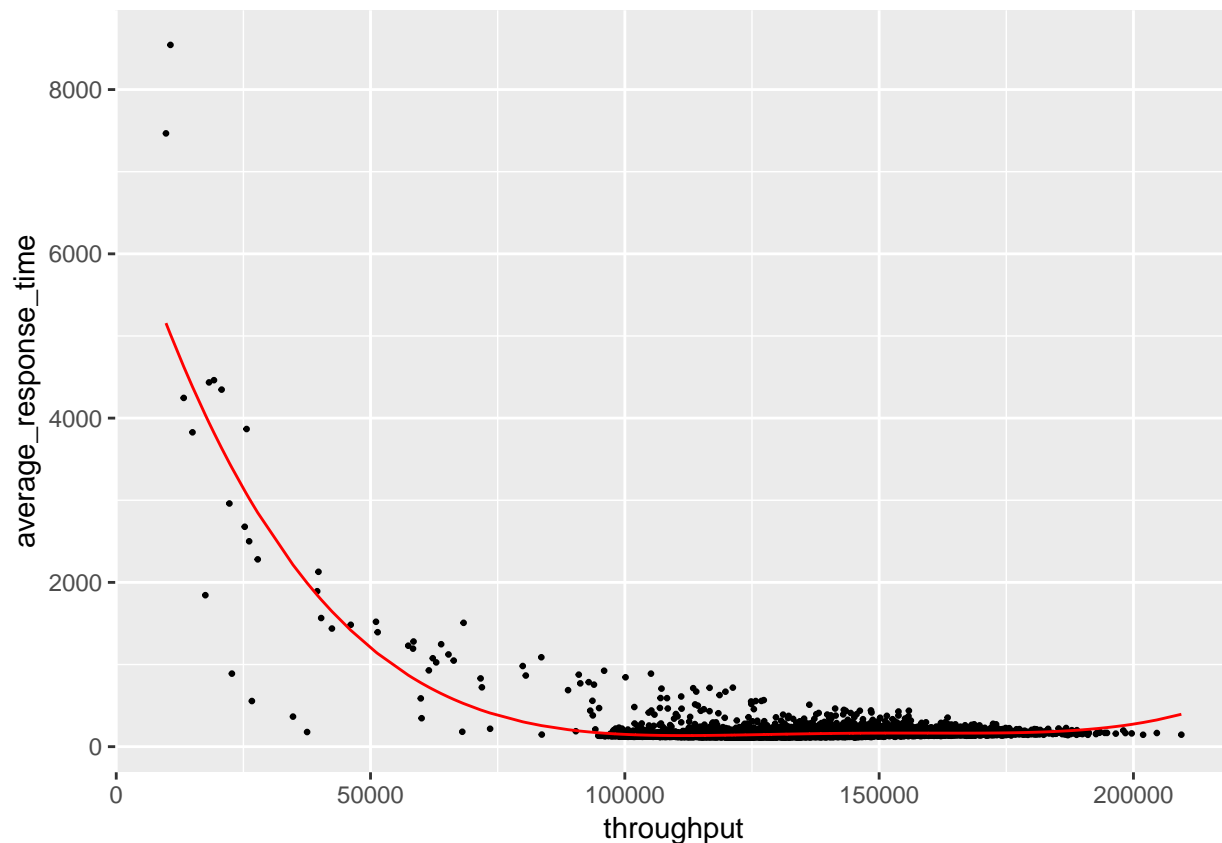
```
ggplot(tcdata, aes(x = begin_time, y = average_response_time)) +
  geom_line(size = 1) +
  scale_x_datetime(breaks = date_breaks("1 day"), labels=date_format("%a-%d",tz=Sys.timezone()))+
  theme_bw()
```



relationship between throughput and average response time

```
#labels = date_format("%a-%d\n%H:%M")
response_curve <- lm(average_response_time ~ poly(throughput,4),data=tcdat)
#response_curve <- nls(average_response_time~ exp(a + b * throughput), data = tcdat, start = list(a = 0,
pred.response<- predict(response_curve,throughput=tcdat$throughput)
tcdat.fit.plot<-cbind(tcdat,pred.response)
```

```
ggplot(tcdat.fit.plot, aes(x = throughput, y = average_response_time)) +
  geom_point(size =0.5) +
  geom_line(color='red',aes(x=throughput,y=pred.response))
```



```
theme_bw()
```

```
## List of 59
## $ line :List of 6
## ..$ colour : chr "black"
## ..$ size : num 0.5
## ..$ linetype : num 1
## ..$ lineend : chr "butt"
## ..$ arrow : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ rect :List of 5
## ..$ fill : chr "white"
## ..$ colour : chr "black"
## ..$ size : num 0.5
## ..$ linetype : num 1
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ text :List of 11
## ..$ family : chr ""
## ..$ face : chr "plain"
## ..$ colour : chr "black"
## ..$ size : num 11
## ..$ hjust : num 0.5
## ..$ vjust : num 0.5
## ..$ angle : num 0
## ..$ lineheight : num 0.9
```

```

## ..$ margin      :Classes 'margin', 'unit'  atomic [1:4] 0 0 0 0
## .. .. ..- attr(*, "valid.unit")= int 8
## .. .. ..- attr(*, "unit")= chr "pt"
## ..$ debug       : logi FALSE
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x   :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 1
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit'  atomic [1:4] 2.75 0 0 0
## .. .. ..- attr(*, "valid.unit")= int 8
## .. .. ..- attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.x.top :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit'  atomic [1:4] 0 0 2.75 0
## .. .. ..- attr(*, "valid.unit")= int 8
## .. .. ..- attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y   :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 1
## ..$ angle       : num 90
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit'  atomic [1:4] 0 2.75 0 0
## .. .. ..- attr(*, "valid.unit")= int 8
## .. .. ..- attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.title.y.right :List of 11
## ..$ family      : NULL
## ..$ face        : NULL

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## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : num -90
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit' atomic [1:4] 0 0 0 2.75
## .. .. - attr(*, "valid.unit")= int 8
## .. .. - attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text      :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : chr "grey30"
## ..$ size        :Class 'rel' num 0.8
## ..$ hjust       : NULL
## ..$ vjust       : NULL
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      : NULL
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x    :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 1
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit' atomic [1:4] 2.2 0 0 0
## .. .. - attr(*, "valid.unit")= int 8
## .. .. - attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.x.top :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : NULL
## ..$ vjust       : num 0
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin      :Classes 'margin', 'unit' atomic [1:4] 0 0 2.2 0
## .. .. - attr(*, "valid.unit")= int 8
## .. .. - attr(*, "unit")= chr "pt"
## ..$ debug       : NULL
## ..$ inherit.blank: logi TRUE

```

```

##   .- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y           :List of 11
##   ..$ family           : NULL
##   ..$ face              : NULL
##   ..$ colour            : NULL
##   ..$ size              : NULL
##   ..$ hjust             : num 1
##   ..$ vjust             : NULL
##   ..$ angle             : NULL
##   ..$ lineheight        : NULL
##   ..$ margin            :Classes 'margin', 'unit'  atomic [1:4] 0 2.2 0 0
##   .. .- attr(*, "valid.unit")= int 8
##   .. .- attr(*, "unit")= chr "pt"
##   ..$ debug             : NULL
##   ..$ inherit.blank: logi TRUE
##   .- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.text.y.right     :List of 11
##   ..$ family           : NULL
##   ..$ face              : NULL
##   ..$ colour            : NULL
##   ..$ size              : NULL
##   ..$ hjust             : num 0
##   ..$ vjust             : NULL
##   ..$ angle             : NULL
##   ..$ lineheight        : NULL
##   ..$ margin            :Classes 'margin', 'unit'  atomic [1:4] 0 0 0 2.2
##   .. .- attr(*, "valid.unit")= int 8
##   .. .- attr(*, "unit")= chr "pt"
##   ..$ debug             : NULL
##   ..$ inherit.blank: logi TRUE
##   .- attr(*, "class")= chr [1:2] "element_text" "element"
## $ axis.ticks            :List of 6
##   ..$ colour            : chr "grey20"
##   ..$ size              : NULL
##   ..$ linetype          : NULL
##   ..$ lineend           : NULL
##   ..$ arrow             : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   .- attr(*, "class")= chr [1:2] "element_line" "element"
## $ axis.ticks.length     :Class 'unit'  atomic [1:1] 2.75
##   .. .- attr(*, "valid.unit")= int 8
##   .. .- attr(*, "unit")= chr "pt"
## $ axis.line             : list()
##   .- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ axis.line.x           : NULL
## $ axis.line.y           : NULL
## $ legend.background     :List of 5
##   ..$ fill              : NULL
##   ..$ colour            : logi NA
##   ..$ size              : NULL
##   ..$ linetype          : NULL
##   ..$ inherit.blank: logi TRUE
##   .- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ legend.margin         :Classes 'margin', 'unit'  atomic [1:4] 5.5 5.5 5.5 5.5

```



```

## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## $ legend.spacing      :Class 'unit'  atomic [1:1] 11
## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## $ legend.spacing.x    : NULL
## $ legend.spacing.y    : NULL
## $ legend.key           :List of 5
## ..$ fill              : chr "white"
## ..$ colour            : logi NA
## ..$ size               : NULL
## ..$ linetype           : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ legend.key.size      :Class 'unit'  atomic [1:1] 1.2
## ..- attr(*, "valid.unit")= int 3
## ..- attr(*, "unit")= chr "lines"
## $ legend.key.height    : NULL
## $ legend.key.width     : NULL
## $ legend.text          :List of 11
## ..$ family            : NULL
## ..$ face               : NULL
## ..$ colour            : NULL
## ..$ size               :Class 'rel'   num 0.8
## ..$ hjust              : NULL
## ..$ vjust              : NULL
## ..$ angle              : NULL
## ..$ lineheight         : NULL
## ..$ margin             : NULL
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.text.align    : NULL
## $ legend.title         :List of 11
## ..$ family            : NULL
## ..$ face               : NULL
## ..$ colour            : NULL
## ..$ size               : NULL
## ..$ hjust              : num 0
## ..$ vjust              : NULL
## ..$ angle              : NULL
## ..$ lineheight         : NULL
## ..$ margin             : NULL
## ..$ debug              : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ legend.title.align   : NULL
## $ legend.position       : chr "right"
## $ legend.direction     : NULL
## $ legend.justification : chr "center"
## $ legend.box            : NULL
## $ legend.box.margin     :Classes 'margin', 'unit'  atomic [1:4] 0 0 0 0
## ..- attr(*, "valid.unit")= int 1
## ..- attr(*, "unit")= chr "cm"

```

```

## $ legend.box.background: list()
##   ..- attr(*, "class")= chr [1:2] "element_blank" "element"
## $ legend.box.spacing :Class 'unit' atomic [1:1] 11
##   .. ..- attr(*, "valid.unit")= int 8
##   .. ..- attr(*, "unit")= chr "pt"
## $ panel.background :List of 5
##   ..$ fill : chr "white"
##   ..$ colour : logi NA
##   ..$ size : NULL
##   ..$ linetype : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ panel.border :List of 5
##   ..$ fill : logi NA
##   ..$ colour : chr "grey20"
##   ..$ size : NULL
##   ..$ linetype : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ panel.spacing :Class 'unit' atomic [1:1] 5.5
##   .. ..- attr(*, "valid.unit")= int 8
##   .. ..- attr(*, "unit")= chr "pt"
## $ panel.spacing.x : NULL
## $ panel.spacing.y : NULL
## $ panel.grid :List of 6
##   ..$ colour : chr "grey92"
##   ..$ size : NULL
##   ..$ linetype : NULL
##   ..$ lineend : NULL
##   ..$ arrow : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ panel.grid.minor :List of 6
##   ..$ colour : NULL
##   ..$ size :Class 'rel' num 0.5
##   ..$ linetype : NULL
##   ..$ lineend : NULL
##   ..$ arrow : logi FALSE
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_line" "element"
## $ panel.ontop : logi FALSE
## $ plot.background :List of 5
##   ..$ fill : NULL
##   ..$ colour : chr "white"
##   ..$ size : NULL
##   ..$ linetype : NULL
##   ..$ inherit.blank: logi TRUE
##   ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ plot.title :List of 11
##   ..$ family : NULL
##   ..$ face : NULL
##   ..$ colour : NULL
##   ..$ size :Class 'rel' num 1.2
##   ..$ hjust : num 0

```

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## ..$ vjust      : num 1
## ..$ angle      : NULL
## ..$ lineheight : NULL
## ..$ margin     :Classes 'margin', 'unit'  atomic [1:4] 0 0 5.5 0
## .. .. .- attr(*, "valid.unit")= int 8
## .. .. .- attr(*, "unit")= chr "pt"
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ plot.subtitle :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        : NULL
## ..$ hjust       : num 0
## ..$ vjust       : num 1
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin     :Classes 'margin', 'unit'  atomic [1:4] 0 0 5.5 0
## .. .. .- attr(*, "valid.unit")= int 8
## .. .. .- attr(*, "unit")= chr "pt"
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ plot.caption  :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        :Class 'rel'  num 0.8
## ..$ hjust       : num 1
## ..$ vjust       : num 1
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin     :Classes 'margin', 'unit'  atomic [1:4] 5.5 0 0 0
## .. .. .- attr(*, "valid.unit")= int 8
## .. .. .- attr(*, "unit")= chr "pt"
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ plot.tag      :List of 11
## ..$ family      : NULL
## ..$ face        : NULL
## ..$ colour      : NULL
## ..$ size        :Class 'rel'  num 1.2
## ..$ hjust       : num 0.5
## ..$ vjust       : num 0.5
## ..$ angle       : NULL
## ..$ lineheight  : NULL
## ..$ margin     : NULL
## ..$ debug      : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ plot.tag.position : chr "topleft"
## $ plot.margin      :Classes 'margin', 'unit'  atomic [1:4] 5.5 5.5 5.5 5.5

```

```

## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## $ strip.background :List of 5
## ..$ fill : chr "grey85"
## ..$ colour : chr "grey20"
## ..$ size : NULL
## ..$ linetype : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_rect" "element"
## $ strip.placement : chr "inside"
## $ strip.text :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : chr "grey10"
## ..$ size :Class 'rel' num 0.8
## ..$ hjust : NULL
## ..$ vjust : NULL
## ..$ angle : NULL
## ..$ lineheight : NULL
## ..$ margin :Classes 'margin', 'unit' atomic [1:4] 4.4 4.4 4.4 4.4
## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ strip.text.x : NULL
## $ strip.text.y :List of 11
## ..$ family : NULL
## ..$ face : NULL
## ..$ colour : NULL
## ..$ size : NULL
## ..$ hjust : NULL
## ..$ vjust : NULL
## ..$ angle : num -90
## ..$ lineheight : NULL
## ..$ margin : NULL
## ..$ debug : NULL
## ..$ inherit.blank: logi TRUE
## ..- attr(*, "class")= chr [1:2] "element_text" "element"
## $ strip.switch.pad.grid:Class 'unit' atomic [1:1] 2.75
## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## $ strip.switch.pad.wrap:Class 'unit' atomic [1:1] 2.75
## ..- attr(*, "valid.unit")= int 8
## ..- attr(*, "unit")= chr "pt"
## - attr(*, "class")= chr [1:2] "theme" "gg"
## - attr(*, "complete")= logi TRUE
## - attr(*, "validate")= logi TRUE

```

```

ggplot(tcdata_fit_plot %>% filter(average_response_time<1000), aes(x = average_response_time, y = through
  geom_point(size =0.5) +
  theme_bw()

```

