Stat. 450 Section 1 or 2: Homework 9

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So how should you complete your homework for this class?

- First thing to do is type all of your information about the problems you do in the text part of your R Notebook.
- Second thing to do is type all of your R code into R chunks that can be run.
- If you load the tidyverse in an R Notebook chunk, be sure to include the "message = FALSE" in the {r}, so {r message = FALSE}.
- Last thing is to spell check your R Notebook. Edit > Check Spelling... or hit the F7 key.

Upload one file to Blackboard.

Homework 9:

```
Read: Chapter 13

Exercises:

Do 13.2.1 Exercises 1, 3
Do 13.3.1 Exercise 1
Do 13.4.6 Exercises 1, 2, 3
```

13.2.1

1. Imagine you wanted to draw (approximately) the route each plane flies from its origin to its destination. What variables would you need? What tables would you need to combine?

Answer: Need flights and airports. From flights get origin and dest. From airports get lat and long.

```r
library(tidyverse)
```

```
## -- Attaching packages ---------------------------------------------------------------------------------

## v ggplot2 3.1.0     v purrr   0.2.5
## v tibble  1.4.2     v dplyr   0.7.7
## v tidyr   0.8.2     v stringr 1.3.1
## v readr   1.1.1     v forcats 0.3.0

## -- Conflicts ------------------------------------------------------------------------------------------
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```r
library(nycflights13)

flights
```

```
## # A tibble: 336,776 x 19
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1  2013     1     1      517            515         2      830
##  2  2013     1     1      533            529         4      850
```

```
## 3 2013 1 1 542 540 2 923
## 4 2013 1 1 544 545 -1 1004
## 5 2013 1 1 554 600 -6 812
## 6 2013 1 1 554 558 -4 740
## 7 2013 1 1 555 600 -5 913
## 8 2013 1 1 557 600 -3 709
## 9 2013 1 1 557 600 -3 838
## 10 2013 1 1 558 600 -2 753
## # ... with 336,766 more rows, and 12 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>
```

```
airports
```

```
## # A tibble: 1,458 x 8
##    faa   name                    lat    lon   alt    tz dst   tzone
##    <chr> <chr>                 <dbl>  <dbl> <int> <dbl> <chr> <chr>
##  1 04G   Lansdowne Airport     41.1  -80.6  1044    -5 A     America/New_~
##  2 06A   Moton Field Municip~  32.5  -85.7   264    -6 A     America/Chic~
##  3 06C   Schaumburg Regional   42.0  -88.1   801    -6 A     America/Chic~
##  4 06N   Randall Airport       41.4  -74.4   523    -5 A     America/New_~
##  5 09J   Jekyll Island Airpo~  31.1  -81.4    11    -5 A     America/New_~
##  6 0A9   Elizabethton Munici~  36.4  -82.2  1593    -5 A     America/New_~
##  7 0G6   Williams County Air~  41.5  -84.5   730    -5 A     America/New_~
##  8 0G7   Finger Lakes Region~  42.9  -76.8   492    -5 A     America/New_~
##  9 0P2   Shoestring Aviation~  39.8  -76.6  1000    -5 U     America/New_~
## 10 0S9   Jefferson County In~  48.1 -123.    108    -8 A     America/Los_~
## # ... with 1,448 more rows
```

```
flights <- flights %>% left_join(airports, c("origin" = "faa"))

flights <- flights %>% left_join(airports, c("dest" = "faa"))

flights
```

```
## # A tibble: 336,776 x 33
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1 2013     1     1      517            515         2      830
##  2 2013     1     1      533            529         4      850
##  3 2013     1     1      542            540         2      923
##  4 2013     1     1      544            545        -1     1004
##  5 2013     1     1      554            600        -6      812
##  6 2013     1     1      554            558        -4      740
##  7 2013     1     1      555            600        -5      913
##  8 2013     1     1      557            600        -3      709
##  9 2013     1     1      557            600        -3      838
## 10 2013     1     1      558            600        -2      753
## # ... with 336,766 more rows, and 26 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>, name.x <chr>, lat.x <dbl>,
## #   lon.x <dbl>, alt.x <int>, tz.x <dbl>, dst.x <chr>, tzone.x <chr>,
## #   name.y <chr>, lat.y <dbl>, lon.y <dbl>, alt.y <int>, tz.y <dbl>,
```

```
## #   dst.y <chr>, tzone.y <chr>
```

3. weather only contains information for the origin (NYC) airports. If it contained weather records for all airports in the USA, what additional relation would it define with flights?

Answer: If all airports were included then the weather at the destination would be available also. Note that the year, month, day, hour would be used for the destination location's weather.

```
weather
```

```
## # A tibble: 26,115 x 15
##    origin  year month   day  hour  temp  dewp humid wind_dir wind_speed
##    <chr>  <dbl> <dbl> <int> <int> <dbl> <dbl> <dbl>    <dbl>      <dbl>
##  1 EWR     2013     1     1     1  39.0  26.1  59.4      270      10.4
##  2 EWR     2013     1     1     2  39.0  27.0  61.6      250       8.06
##  3 EWR     2013     1     1     3  39.0  28.0  64.4      240      11.5
##  4 EWR     2013     1     1     4  39.9  28.0  62.2      250      12.7
##  5 EWR     2013     1     1     5  39.0  28.0  64.4      260      12.7
##  6 EWR     2013     1     1     6  37.9  28.0  67.2      240      11.5
##  7 EWR     2013     1     1     7  39.0  28.0  64.4      240      15.0
##  8 EWR     2013     1     1     8  39.9  28.0  62.2      250      10.4
##  9 EWR     2013     1     1     9  39.9  28.0  62.2      260      15.0
## 10 EWR     2013     1     1    10  41    28.0  59.6      260      13.8
## # ... with 26,105 more rows, and 5 more variables: wind_gust <dbl>,
## #   precip <dbl>, pressure <dbl>, visib <dbl>, time_hour <dttm>
```

```
flights
```

```
## # A tibble: 336,776 x 33
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1  2013     1     1      517            515         2      830
##  2  2013     1     1      533            529         4      850
##  3  2013     1     1      542            540         2      923
##  4  2013     1     1      544            545        -1     1004
##  5  2013     1     1      554            600        -6      812
##  6  2013     1     1      554            558        -4      740
##  7  2013     1     1      555            600        -5      913
##  8  2013     1     1      557            600        -3      709
##  9  2013     1     1      557            600        -3      838
## 10  2013     1     1      558            600        -2      753
## # ... with 336,766 more rows, and 26 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>, name.x <chr>, lat.x <dbl>,
## #   lon.x <dbl>, alt.x <int>, tz.x <dbl>, dst.x <chr>, tzone.x <chr>,
## #   name.y <chr>, lat.y <dbl>, lon.y <dbl>, alt.y <int>, tz.y <dbl>,
## #   dst.y <chr>, tzone.y <chr>
```

13.3.1.

1. Add a surrogate key to flights.

```
flights
```

```
## # A tibble: 336,776 x 33
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1  2013     1     1      517            515         2      830
##  2  2013     1     1      533            529         4      850
##  3  2013     1     1      542            540         2      923
##  4  2013     1     1      544            545        -1     1004
##  5  2013     1     1      554            600        -6      812
##  6  2013     1     1      554            558        -4      740
##  7  2013     1     1      555            600        -5      913
##  8  2013     1     1      557            600        -3      709
##  9  2013     1     1      557            600        -3      838
## 10  2013     1     1      558            600        -2      753
## # ... with 336,766 more rows, and 26 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>, name.x <chr>, lat.x <dbl>,
## #   lon.x <dbl>, alt.x <int>, tz.x <dbl>, dst.x <chr>, tzone.x <chr>,
## #   name.y <chr>, lat.y <dbl>, lon.y <dbl>, alt.y <int>, tz.y <dbl>,
## #   dst.y <chr>, tzone.y <chr>
```

```
flights %>% mutate(index = row_number())
```

```
## # A tibble: 336,776 x 34
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1  2013     1     1      517            515         2      830
##  2  2013     1     1      533            529         4      850
##  3  2013     1     1      542            540         2      923
##  4  2013     1     1      544            545        -1     1004
##  5  2013     1     1      554            600        -6      812
##  6  2013     1     1      554            558        -4      740
##  7  2013     1     1      555            600        -5      913
##  8  2013     1     1      557            600        -3      709
##  9  2013     1     1      557            600        -3      838
## 10  2013     1     1      558            600        -2      753
## # ... with 336,766 more rows, and 27 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>, name.x <chr>, lat.x <dbl>,
## #   lon.x <dbl>, alt.x <int>, tz.x <dbl>, dst.x <chr>, tzone.x <chr>,
## #   name.y <chr>, lat.y <dbl>, lon.y <dbl>, alt.y <int>, tz.y <dbl>,
## #   dst.y <chr>, tzone.y <chr>, index <int>
```

13.4.6

1. Compute the average delay by destination, then join on the airports data frame so you can show the spatial distribution of delays. Here's an easy way to draw a map of the United States:

```
flights
```

```
## # A tibble: 336,776 x 33
##     year month   day dep_time sched_dep_time dep_delay arr_time
##    <int> <int> <int>    <int>          <int>     <dbl>    <int>
##  1  2013     1     1      517            515         2      830
##  2  2013     1     1      533            529         4      850
##  3  2013     1     1      542            540         2      923
##  4  2013     1     1      544            545        -1     1004
##  5  2013     1     1      554            600        -6      812
##  6  2013     1     1      554            558        -4      740
##  7  2013     1     1      555            600        -5      913
##  8  2013     1     1      557            600        -3      709
##  9  2013     1     1      557            600        -3      838
## 10  2013     1     1      558            600        -2      753
## # ... with 336,766 more rows, and 26 more variables: sched_arr_time <int>,
## #   arr_delay <dbl>, carrier <chr>, flight <int>, tailnum <chr>,
## #   origin <chr>, dest <chr>, air_time <dbl>, distance <dbl>, hour <dbl>,
## #   minute <dbl>, time_hour <dttm>, name.x <chr>, lat.x <dbl>,
## #   lon.x <dbl>, alt.x <int>, tz.x <dbl>, dst.x <chr>, tzone.x <chr>,
## #   name.y <chr>, lat.y <dbl>, lon.y <dbl>, alt.y <int>, tz.y <dbl>,
## #   dst.y <chr>, tzone.y <chr>
```

```
delays <- flights %>% group_by(dest) %>%
  summarise(delay_ave = mean(arr_delay, na.rm = TRUE))
delays
```

```
## # A tibble: 105 x 2
##    dest  delay_ave
##    <chr>     <dbl>
##  1 ABQ        4.38
##  2 ACK        4.85
##  3 ALB       14.4
##  4 ANC       -2.5
##  5 ATL       11.3
##  6 AUS        6.02
##  7 AVL        8.00
##  8 BDL        7.05
##  9 BGR        8.03
## 10 BHM       16.9
## # ... with 95 more rows
```

```
airports
```

```
## # A tibble: 1,458 x 8
##    faa   name                   lat    lon   alt    tz dst   tzone
##    <chr> <chr>                <dbl>  <dbl> <int> <dbl> <chr> <chr>
##  1 04G   Lansdowne Airport     41.1  -80.6  1044    -5 A     America/New_~
```

```
##  2 06A   Moton Field Municip~  32.5  -85.7   264    -6 A     America/Chic~
##  3 06C   Schaumburg Regional   42.0  -88.1   801    -6 A     America/Chic~
##  4 06N   Randall Airport       41.4  -74.4   523    -5 A     America/New_~
##  5 09J   Jekyll Island Airpo~  31.1  -81.4    11    -5 A     America/New_~
##  6 0A9   Elizabethton Munici~  36.4  -82.2  1593    -5 A     America/New_~
##  7 0G6   Williams County Air~  41.5  -84.5   730    -5 A     America/New_~
##  8 0G7   Finger Lakes Region~  42.9  -76.8   492    -5 A     America/New_~
##  9 0P2   Shoestring Aviation~  39.8  -76.6  1000    -5 U     America/New_~
## 10 0S9   Jefferson County In~  48.1 -123.    108    -8 A     America/Los_~
## # ... with 1,448 more rows
```

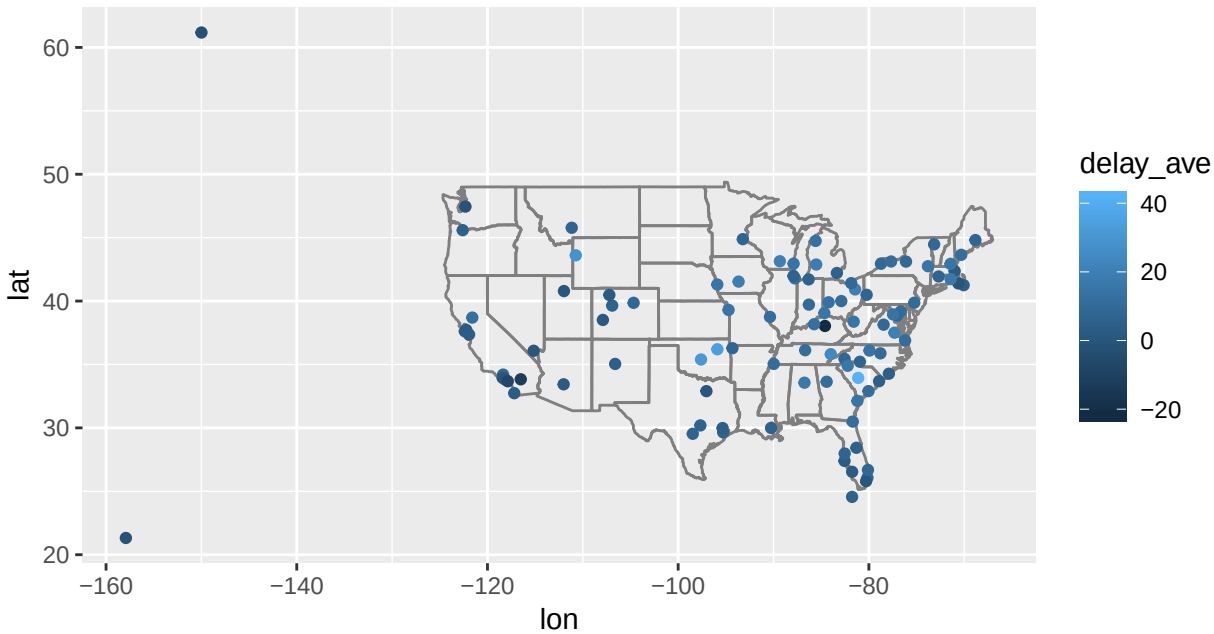
```r
delays <- delays %>% inner_join(airports, by = c("dest" = "faa"))
delays
```

```
## # A tibble: 101 x 9
##    dest  delay_ave name              lat    lon   alt    tz dst   tzone
##    <chr>     <dbl> <chr>           <dbl>  <dbl> <int> <dbl> <chr> <chr>
##  1 ABQ        4.38 Albuquerque In~  35.0 -107.   5355    -7 A     America~
##  2 ACK        4.85 Nantucket Mem    41.3  -70.1    48    -5 A     America~
##  3 ALB       14.4  Albany Intl      42.7  -73.8   285    -5 A     America~
##  4 ANC       -2.5  Ted Stevens An~  61.2 -150.    152    -9 A     America~
##  5 ATL       11.3  Hartsfield Jac~  33.6  -84.4  1026    -5 A     America~
##  6 AUS        6.02 Austin Bergstr~  30.2  -97.7   542    -6 A     America~
##  7 AVL        8.00 Asheville Regi~  35.4  -82.5  2165    -5 A     America~
##  8 BDL        7.05 Bradley Intl     41.9  -72.7   173    -5 A     America~
##  9 BGR        8.03 Bangor Intl      44.8  -68.8   192    -5 A     America~
## 10 BHM       16.9  Birmingham Intl  33.6  -86.8   644    -6 A     America~
## # ... with 91 more rows
```

```r
delays  %>%
  ggplot(aes(lon, lat, color = delay_ave)) +
    borders("state") +
    geom_point() +
    coord_quickmap()
```

```
##
## Attaching package: 'maps'

## The following object is masked from 'package:purrr':
##
##     map
```



2. Add the location of the origin and destination (i.e. the lat and lon) to flights.

```
airports
```

```
## # A tibble: 1,458 x 8
##    faa   name                    lat    lon   alt    tz dst   tzone
##    <chr> <chr>                 <dbl>  <dbl> <int> <dbl> <chr> <chr>
##  1 04G   Lansdowne Airport      41.1  -80.6  1044    -5 A     America/New_~
##  2 06A   Moton Field Municip~   32.5  -85.7   264    -6 A     America/Chic~
##  3 06C   Schaumburg Regional    42.0  -88.1   801    -6 A     America/Chic~
##  4 06N   Randall Airport        41.4  -74.4   523    -5 A     America/New_~
##  5 09J   Jekyll Island Airpo~   31.1  -81.4    11    -5 A     America/New_~
##  6 0A9   Elizabethton Munici~   36.4  -82.2  1593    -5 A     America/New_~
##  7 0G6   Williams County Air~   41.5  -84.5   730    -5 A     America/New_~
##  8 0G7   Finger Lakes Region~   42.9  -76.8   492    -5 A     America/New_~
##  9 0P2   Shoestring Aviation~   39.8  -76.6  1000    -5 U     America/New_~
## 10 0S9   Jefferson County In~   48.1 -123.    108    -8 A     America/Los_~
## # ... with 1,448 more rows
```

```
airports_loc <- airports %>%
  select(faa, lat, lon)

flights %>%
  select(year:day, hour, origin, dest) %>%
  left_join(
    airports_loc,
    by = c("origin" = "faa")
  ) %>%
  left_join(
    airports_loc,
    by = c("dest" = "faa")
  )
```

```
## # A tibble: 336,776 x 10
##     year month   day  hour origin dest  lat.x lon.x lat.y lon.y
##    <int> <int> <int> <dbl> <chr>  <chr> <dbl> <dbl> <dbl> <dbl>
##  1  2013     1     1     5 EWR    IAH    40.7 -74.2  30.0 -95.3
##  2  2013     1     1     5 LGA    IAH    40.8 -73.9  30.0 -95.3
##  3  2013     1     1     5 JFK    MIA    40.6 -73.8  25.8 -80.3
##  4  2013     1     1     5 JFK    BQN    40.6 -73.8  NA    NA
##  5  2013     1     1     6 LGA    ATL    40.8 -73.9  33.6 -84.4
##  6  2013     1     1     5 EWR    ORD    40.7 -74.2  42.0 -87.9
##  7  2013     1     1     6 EWR    FLL    40.7 -74.2  26.1 -80.2
##  8  2013     1     1     6 LGA    IAD    40.8 -73.9  38.9 -77.5
##  9  2013     1     1     6 JFK    MCO    40.6 -73.8  28.4 -81.3
## 10  2013     1     1     6 LGA    ORD    40.8 -73.9  42.0 -87.9
## # ... with 336,766 more rows
```

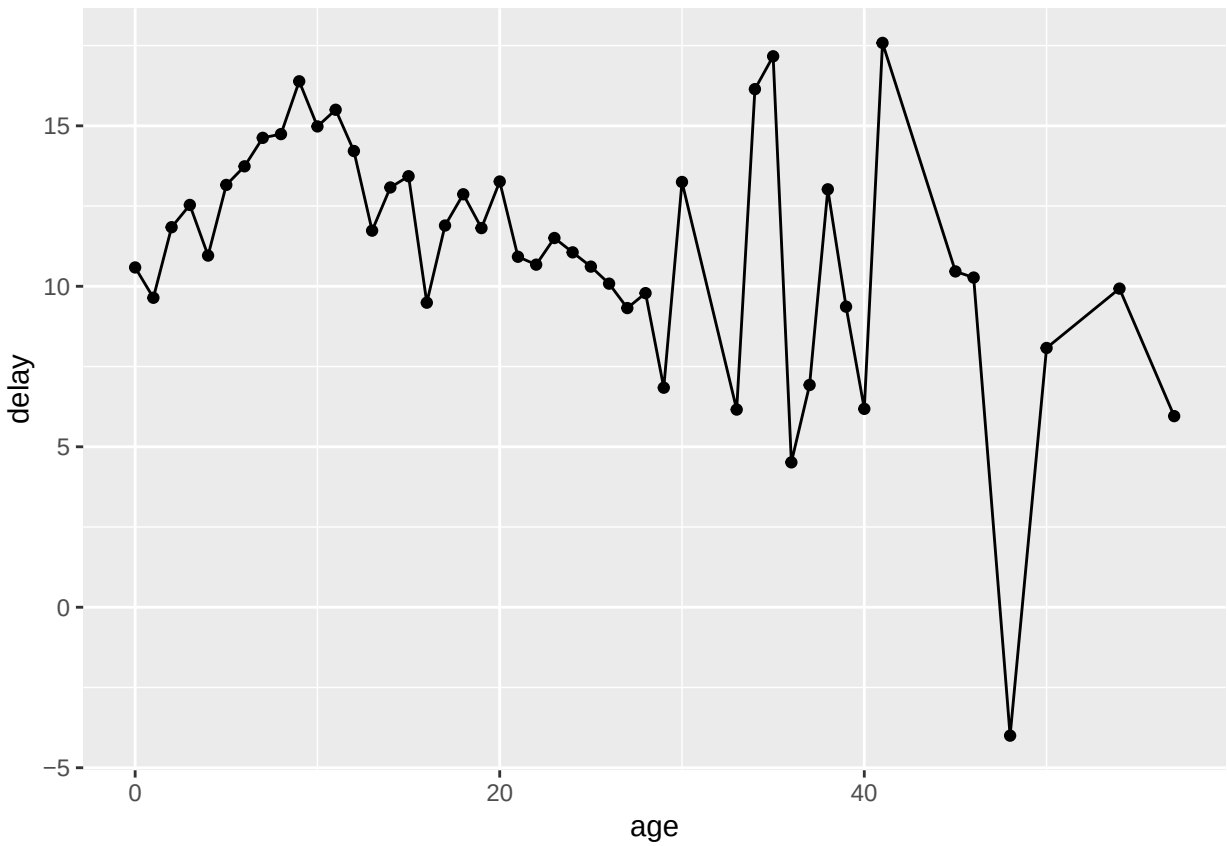
3. Is there a relationship between the age of a plane and its delays?

```r
plane_ages <-
  planes %>%
  mutate(age = 2013 - year) %>%
  select(tailnum, age)

flights %>%
  inner_join(plane_ages, by = "tailnum") %>%
  group_by(age) %>%
  filter(!is.na(dep_delay)) %>%
  summarise(delay = mean(dep_delay)) %>%
  ggplot(aes(x = age, y = delay)) +
  geom_point() +
  geom_line()
```

```
## Warning: Removed 1 rows containing missing values (geom_point).
```

```
## Warning: Removed 1 rows containing missing values (geom_path).
```


15
10
5
0
−5
delay
0
20
40
age