Dashboards & Apps with Shiny

Mine Çetinkaya-Rundel @

@minebocek
mine-cetinkaya-rundel
mine@rstudio.com

Workshop materials

OPTION 1

RStudio Cloud

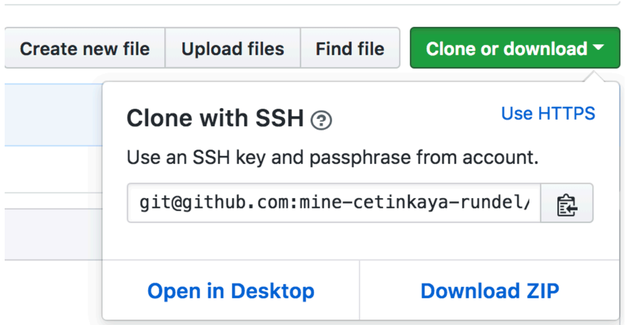
bit.ly/shiny-rlphl

log in and sit tight

OPTION 2

RStudio

bit.ly/shiny-rlphl-git



1. clone or download

2. launch `rladies-phl-shiny.Rproj`

Shiny

Meet & greet

Mine Çetinkaya-Rundel

Associate Professor, Duke Statistical Science

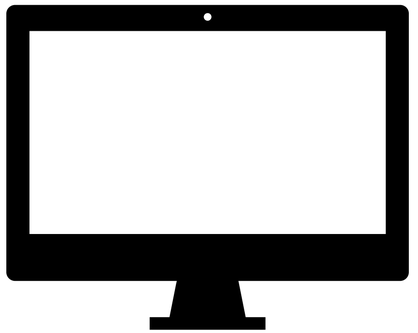
Data Scientist & Professional Educator, RStudio

Overview

- 01 - Building dashboards with flexdashboard
- 02 - Getting started with shiny
- 03 - Understanding reactivity
- Lots of info!
- Lots of “your turn” breaks

01
Building dashboards with `flexdashboard`

gallery.shinyapps.io/un-women-dash



DEMO

Dashboards

- Built in layouts and UI elements
- Good venue for displaying automatically updating data
- May or may not be interactive

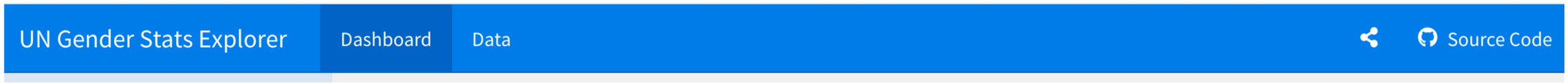
UI

- Static:
  - R code runs once and generates an HTML page
  - Generation of this HTML can be scheduled
- Dynamic:
  - Client web browser connects to an R session running on server
  - User input causes server to do things and send information back to client
  - Interactivity can be on client and server
  - Can update data in real time
- User potentially can do anything that R can do

Building a dashboard

1. Set up the YAML

```
---
title: "UN Women Stats Explorer"
output:
  flexdashboard::flex_dashboard:
    orientation: rows
    social: menu
    source_code: https://github.com/mine-cetinkaya-rundel/rladies-phl-shiny/blob/master/01-flexdash/un-women-dash.Rmd
runtime: shiny
---
```



2. Pick a layout

```
---
title: "Row Orientation"
output:
  flexdashboard::flex_dashboard:
    orientation: rows
---

Row
-------------------------------------

### Chart 1

```{r}

```

Row

Chart 2

```{r}

```

Chart 3

```{r}

```

```

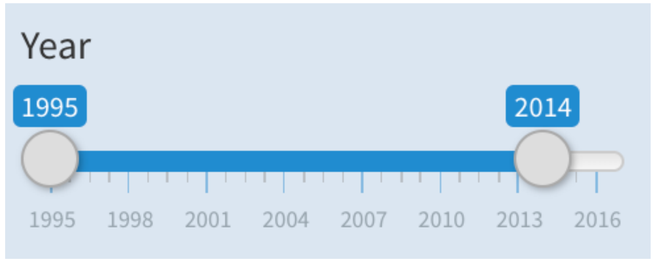

# 3. Use R Markdown and/or Shiny code to add components

```
selectInput(inputId = "x", label = "X-axis",
  choices = c("Average number of hours spent on unpaid domestic
and care work"
              = "hrs_unpaid_dom_care_work",
            "Average number of hours spent on paid and unpaid
domestic and care work combined"
              = "hrs_dom_care_work",...),
  selected = "labor_force")

renderPlot({
  ggplot(data = sel_data(),
         mapping = aes_string(x = input$x, y = input$y, color = "region")
    geom_point(size = 2, alpha = 0.8) +
    theme_minimal() +
    labs(x = xlab(), y = ylab(), color = "Region")
  })
```

Your turn

```
sliderInput(inputId = "year", label = "Year",
            min = min_year, max = max_year,
            value = c(2001, max_year), step = 1, sep = "")
```



- Open `un-women-dash.Rmd`
- Change the default selection of years to the `min_year` to 2014
- Run the app
- Select view mode in the drop down menu next to Run App to Preview in Viewer Pane
- Rerun the app

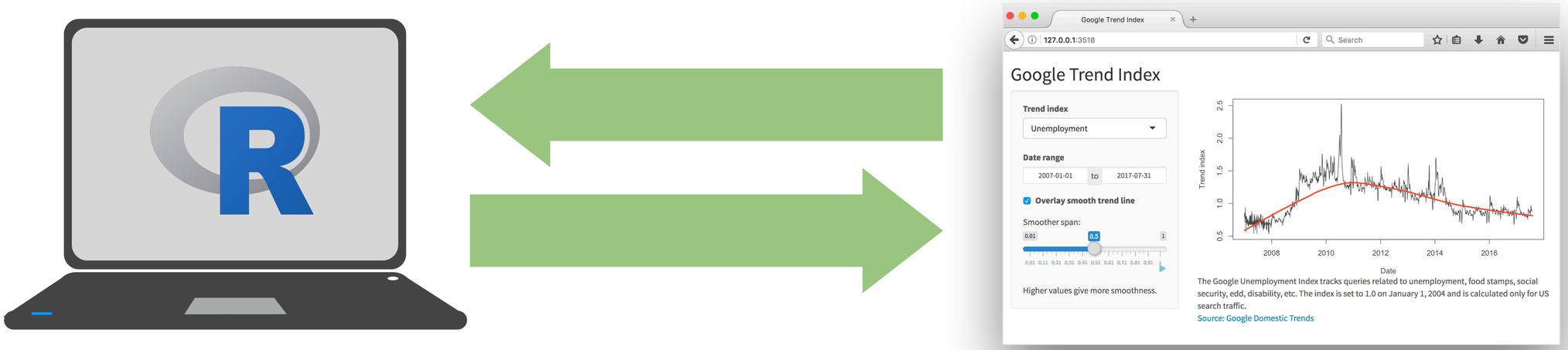
3m 00s

02
Getting started with `shiny`

High level view

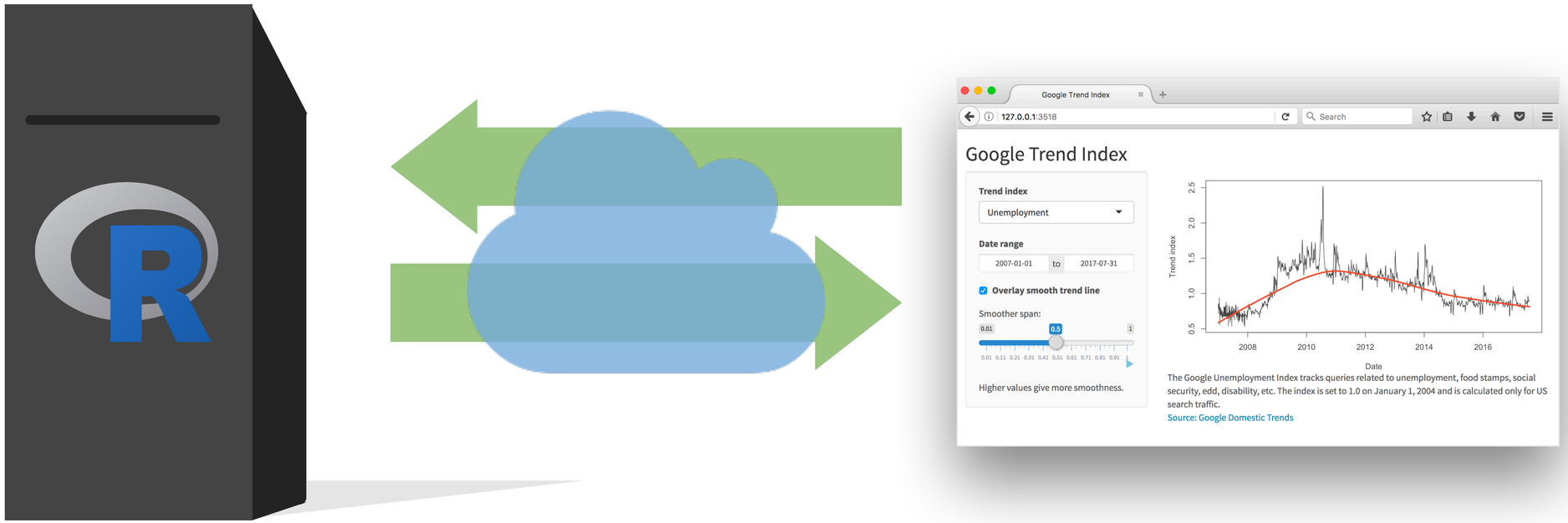
Every Shiny app has a webpage that the user visits, and behind this webpage there is a computer that serves this webpage by running R.

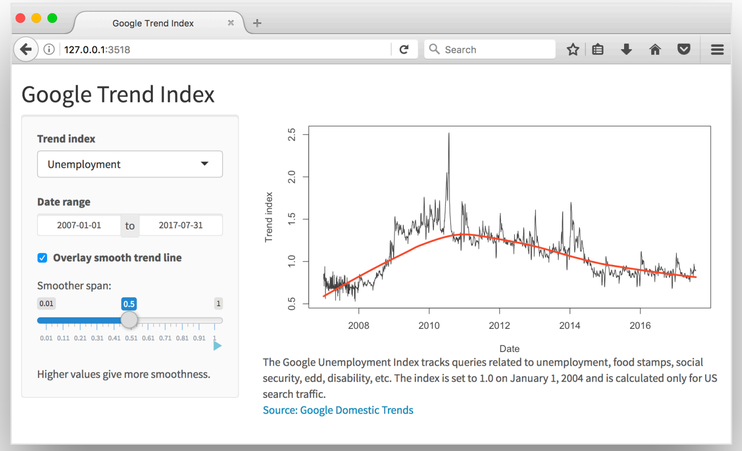
When running your app locally, the computer serving your app is your computer.



When your app is deployed,

the computer serving your app is a web server.





Server instructions

User interface

Anatomy of a Shiny app

What's in an app?

```
library(shiny)

ui <- fluidPage()

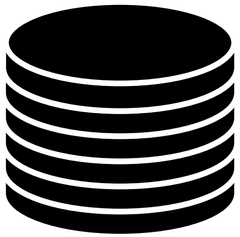

server <- function(input, output) {}


shinyApp(ui = ui, server = server)
```

User interface
controls the layout and appearance of app

Server function
contains instructions needed to build app

National Health and Nutrition Examination Survey



`NHANES::NHANES`

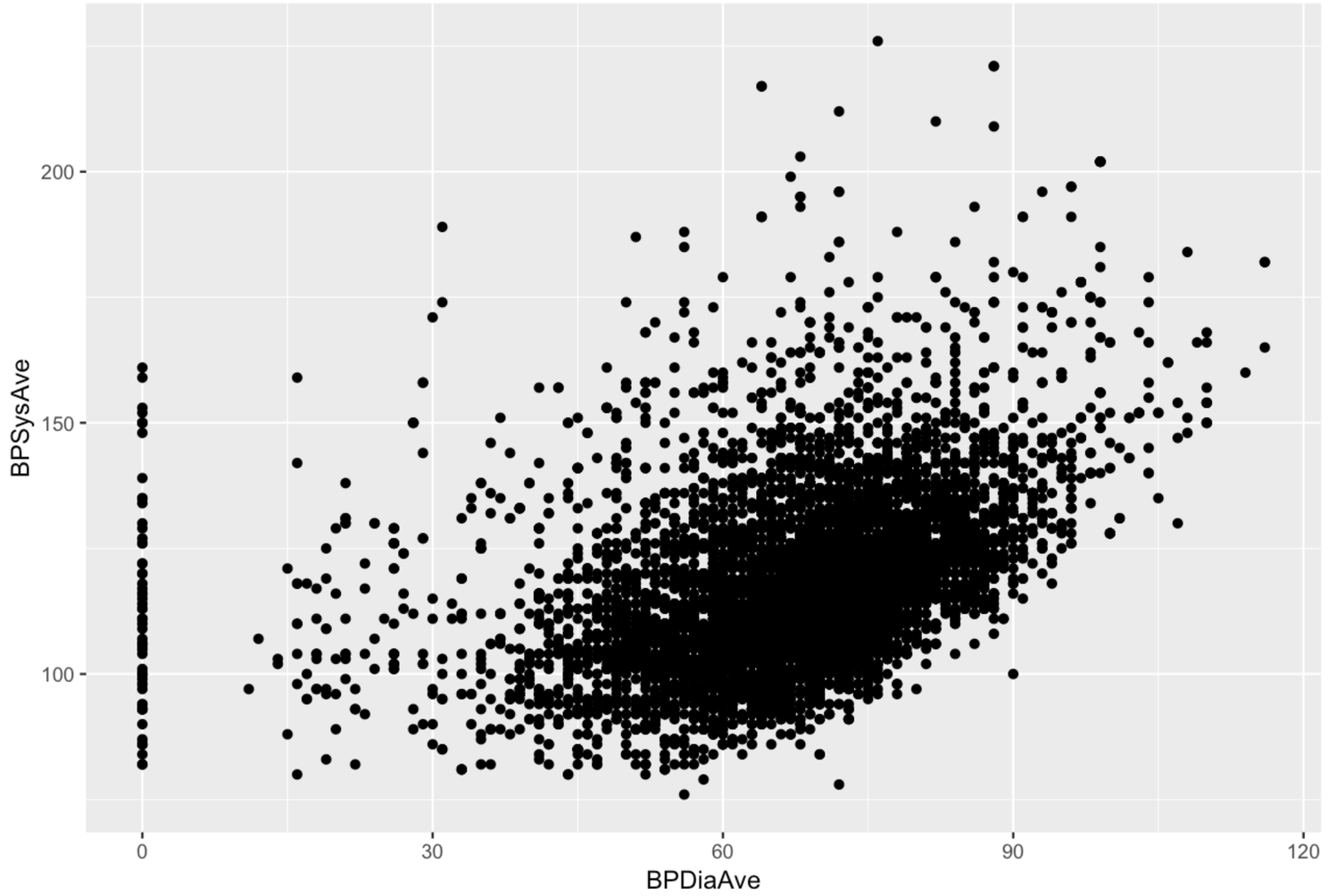
Data from the 2009 - 2010 and 2011 - 2012 surveys on 10,000 participants and 76 variables collected on them

Y-axis:

BPSysAve

X-axis:

BPDiaAve



App template

```
library(shiny)
library(tidyverse)
library(NHANES)
ui <- fluidPage()

server <- function(input, output) {}

shinyApp(ui = ui, server = server)
```

User interface

```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
```

```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPDiaAve"),
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
)
```

Create fluid page layout

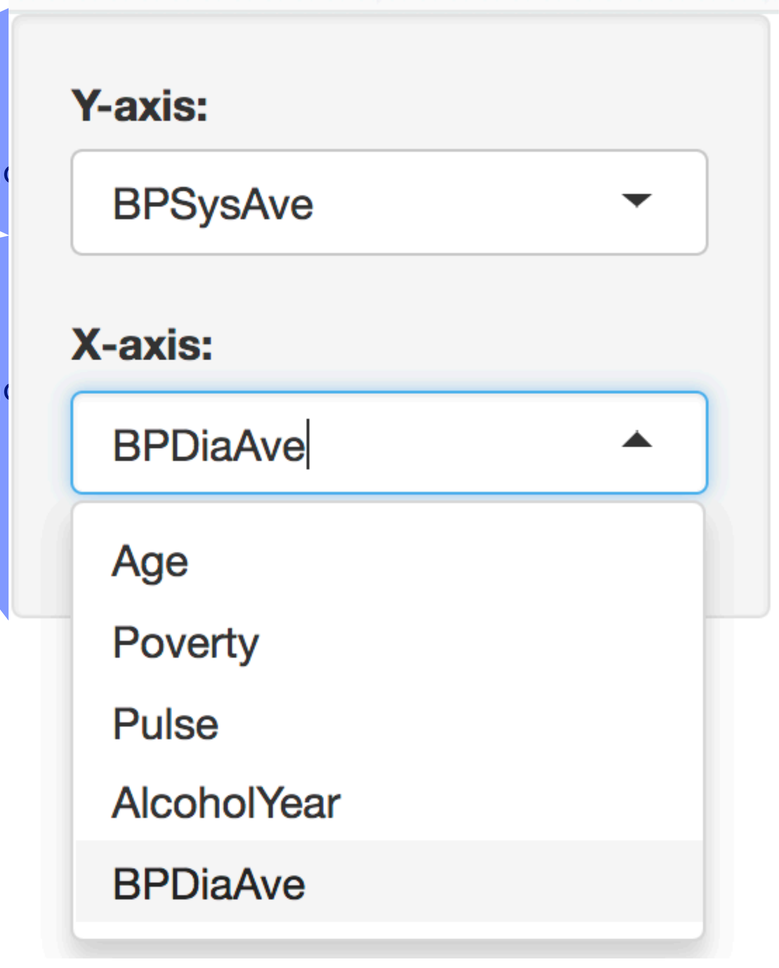
```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPDiaAve"),
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
)
```

Create a layout with a sidebar and main area

```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPDiaAve"),
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
)
```

Create a sidebar panel containing **input** controls that can in turn be passed to `sidebarLayout`

```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "Alcoho
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "Alcoho
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
)
```



```r
# Define UI
ui <- fluidPage(

  # Sidebar layout with a input and output definitions
  sidebarLayout(
    # Inputs: Select variables to plot
    sidebarPanel(
      # Select variable for y-axis
      selectInput(inputId = "y", label = "Y-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPSysAve"),
                  selected = "BPSysAve"),
      # Select variable for x-axis
      selectInput(inputId = "x", label = "X-axis:",
                  choices = c("Age", "Poverty", "Pulse", "AlcoholYear", "BPDiaAve"),
                  selected = "BPDiaAve")
    ),

    # Output: Show scatterplot
    mainPanel(
      plotOutput(outputId = "scatterplot")
    )
  )
)
```

Create a main panel containing **output** elements that get created in the server function can in turn be passed to `sidebarLayout`

Server

```
# Define server function
server <- function(input, output) {

  # Create the scatterplot object the plotOutput function is expecting
  output$scatterplot <- renderPlot({
    ggplot(data = NHANES, aes_string(x = input$x, y = input$y)) +
      geom_point()
  })
}
```

```
# Define server function
server <- function(input, output) {

  # Create the scatterplot object the plotOutput function is expecting
  output$scatterplot <- renderPlot({
    ggplot(data = NHANES, aes_string(x = input$x, y = input$y)) +
      geom_point()
  })
}
```

Contains instructions needed to build app

```
# Define server function
server <- function(input, output) {


  # Create the scatterplot object the plotOutput fun
  output$scatterplot <- renderPlot({
    ggplot(data = NHANES, aes_string(x = input$x, y
      geom_point()
  })
}
```

Renders a **reactive** plot that is suitable for assigning to an output slot

```
# Define server function
server <- function(input, output) {


  # Create the scatterplot object the plotOutput function is expecting
  output$scatterplot <- renderPlot({
    ggplot(data = NHANES, aes_string(x = input$x, y = input$y)) +
      geom_point()
  })
}
```

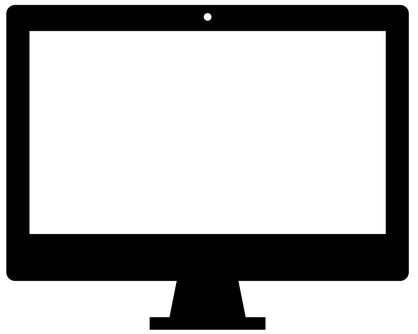
Good ol' ggplot2 code, with **input**s from UI

UI + Server

```
# Create the Shiny app object
shinyApp(ui = ui, server = server)
```

Putting it all together...

`nhanes-01.R`



DEMO

Your turn

- Add new select menu to color the points by
  - `inputId = "z"`
  - `label = "Color by:"`
  - `choices = c("Gender", "Depressed", "SleepTrouble", "SmokeNow", "Marijuana")`
  - `selected = "SleepTrouble"`
- Use this variable in the aesthetics of the `ggplot` function as the color argument to color the points by
- Run the app in the Viewer Pane
- Compare your code / output with the person sitting next to / nearby you

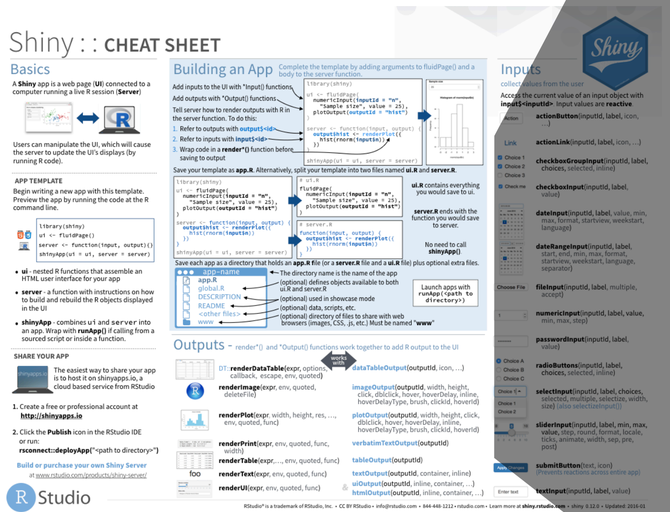
5m 00s

Solution to the previous exercise

`nhanes-02.R`

SOLUTION

Inputs



Action — **actionButton**(inputId, label, icon, …)

Link — **actionLink**(inputId, label, icon, …)

Choice 1 / Choice 2 / Choice 3 — **checkboxGroupInput**(inputId, label, choices, selected, inline)

Check me — **checkboxInput**(inputId, label, value)

2015-06-08 — **dateInput**(inputId, label, value, min, max, format, startview, weekstart, language)

2015-06-08 to 2015-06-08 — **dateRangeInput**(inputId, label, start, end, min, max, format, startview, weekstart, language, separator)

Choose File — **fileInput**(inputId, label, multiple, accept)

1 — **numericInput**(inputId, label, value, min, max, step)

•••••••• — **passwordInput**(inputId, label, value)

Choice A / Choice B / Choice C — **radioButtons**(inputId, label, choices, selected, inline)

Choice 1 / Choice 1 / Choice 2 — **selectInput**(inputId, label, choices, selected, multiple, selectize, width, size) (also **selectizeInput()**)

0 5 10 / 0 2 4 6 8 10 — **sliderInput**(inputId, label, min, max, value, step, round, format, locale, ticks, animate, width, sep, pre, post)

Apply Changes — **submitButton**(text, icon)
(Prevents reactions across entire app)

Enter text — **textInput**(inputId, label, value)

Your turn

- Add new input variable to control the alpha level of the points
  - This should be a `sliderInput`
    - See shiny.rstudio.com/reference/shiny/latest/ for help
  - Values should range from 0 to 1
  - Set a default value that looks good
- Use this variable in the geom of the `ggplot` function as the alpha argument
- Run the app in a new window
- Compare your code / output with the person sitting next to / nearby you

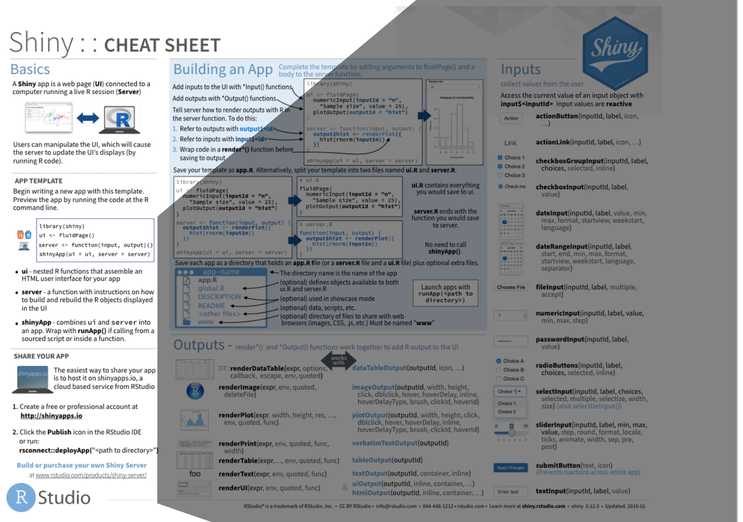
5m 00s

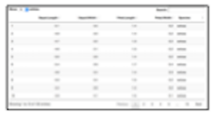
Solution to the previous exercise

`nhanes-03.R`

SOLUTION

Outputs





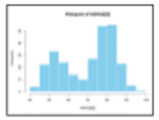
DT::**renderDataTable**(expr, options, callback, escape, env, quoted)

works with

dataTableOutput(outputId, icon, …)

renderImage(expr, env, quoted, deleteFile)

imageOutput(outputId, width, height, click, dblclick, hover, hoverDelay, hoverDelayType, brush, clickId, hoverId, inline)



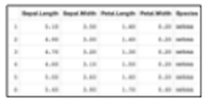
renderPlot(expr, width, height, res, …, env, quoted, func)

plotOutput(outputId, width, height, click, dblclick, hover, hoverDelay, hoverDelayType, brush, clickId, hoverId, inline)

```
'data.frame':  3 obs. of  2 variables:
$ Sepal.Length: num  5.1 4.9 4.7
$ Sepal.Width : num  3.5 3 3.2
```

renderPrint(expr, env, quoted, func, width)

verbatimTextOutput(outputId)



renderTable(expr,…, env, quoted, func)

tableOutput(outputId)

foo

renderText(expr, env, quoted, func)

textOutput(outputId, container, inline)

renderUI(expr, env, quoted, func)

uiOutput(outputId, inline, container, …)
& **htmlOutput**(outputId, inline, container, …)

Which `render*` and `*Output` function duo is used to add this table to the app?

```
library(shiny)
library(tidyverse)
library(NHANES)
ui <- fluidPage(

    DT::dataTableOutput()

)

server <- function(input, output) {

    DT::renderDataTable()

}

shinyApp(ui = ui, server = server)
```

Your turn

- Create a new output item using `DT::renderDataTable`.
- Show first seven columns of NHANES data, show 10 rows at a time, and hide row names, e.g.
  - `data = NHANES[, 1:7]`
  - `options = list(pageLength = 10)`
  - `rownames = FALSE`
- Add a `DT::dataTableOutput` to the main panel
- Run the app in a new Window
- Compare your code / output with the person sitting next to / nearby you
- **Stretch goal:** Make the number of columns visible in the table a user defined input

5m 00s

Solution to the previous exercise

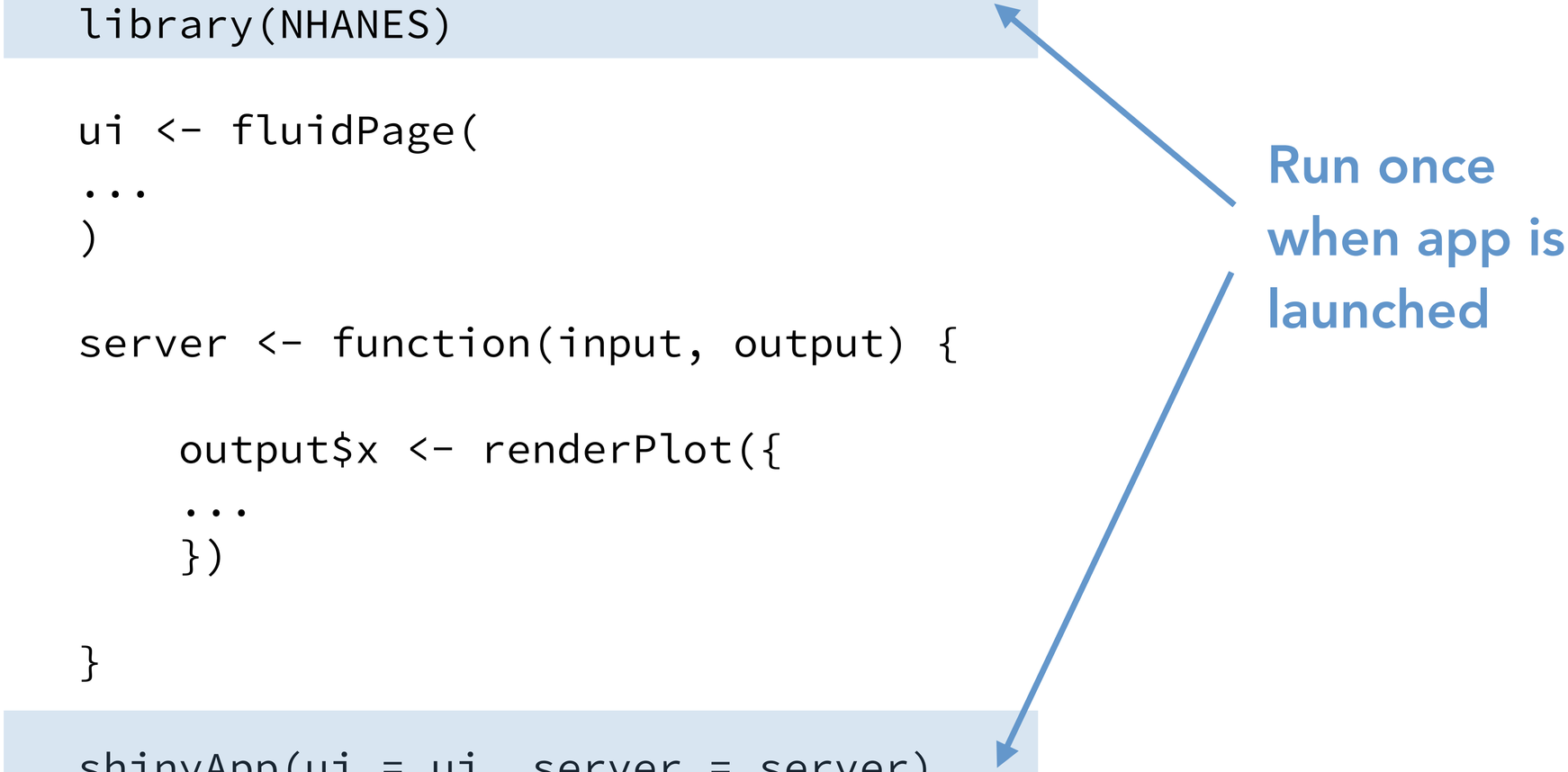
`nhanes-04.R`

SOLUTION

Execution

Where you place code in your app will determine how many times they are run (or re-run), which will in turn affect the performance of your app, since Shiny will run some sections your app script more often than others.

```
library(shiny)
library(tidyverse)
library(NHANES)

ui <- fluidPage(
...
)

server <- function(input, output) {

    output$x <- renderPlot({
    ...
    })

}

shinyApp(ui = ui, server = server)
```



```
library(shiny)
library(tidyverse)
library(NHANES)

ui <- fluidPage(
...
)

server <- function(input, output) {

    output$x <- renderPlot({
    ...
    })

}

shinyApp(ui = ui, server = server)
```

Run once each time a user visits the app

```
library(shiny)
library(tidyverse)
library(NHANES)

ui <- fluidPage(
...
)

server <- function(input, output) {

    output$x <- renderPlot({
    ...
    })

}

shinyApp(ui = ui, server = server)
```

Run once
each time a user
changes a widget that
output$x depends on

03
Understanding reactivity

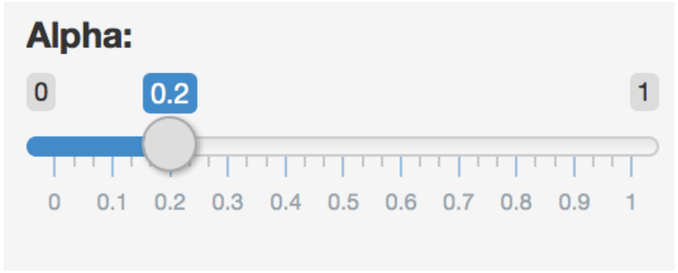
Reactivity 101

Reactions

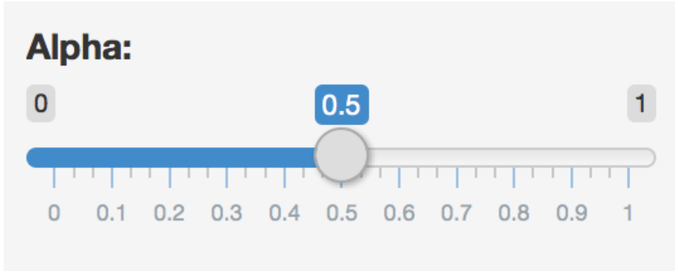
The **input$** list stores the current value of each input object under its name.

```
# Set alpha level
sliderInput(inputId = "alpha",
            label = "Alpha:",
            min = 0, max = 1,
            value = 0.5)
```

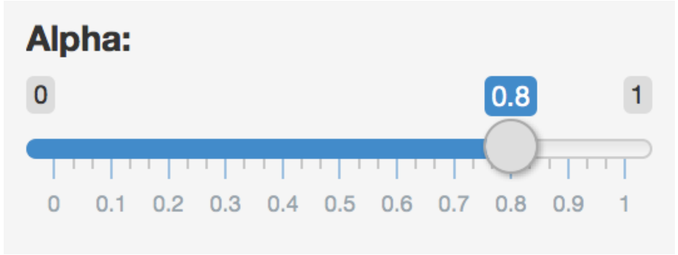
input$alpha



input$alpha = 0.2



input$alpha = 0.5



input$alpha = 0.8

Reactivity 101

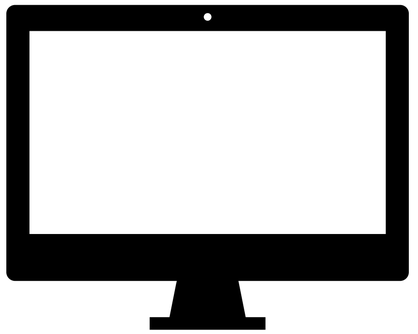
Reactivity automatically occurs when an input value
is used to render an output object

```
# Define server function required to create the scatterplot
server <- function(input, output) {
   # Create the scatterplot object the plotOutput function is expecting
    output$scatterplot <- renderPlot(
     ggplot(data = NHANES, aes_string(x = input$x, y = input$y,
                                      color = input$z)) +
       geom_point(alpha = input$alpha)
    )
}
```

Reactive flow

Suppose you want the option to plot only certain education level(s) as well as report how many such participants are plotted:

1. Add a UI element for the user to select which education level(s) they want to plot
2. Filter for chosen education level(s) and save as a new (reactive) expression
3. Use new data frame (which is reactive) for plotting
4. Use new data frame (which is reactive) also for reporting number of observations



DEMO

1. Add a UI element for the user to select which education level(s) they want to plot

```
# Select which education level(s) to plot
checkboxGroupInput(inputId = "education",
                   label = "Select education level(s):”,
                   choices = levels(NHANES$Education),
                   selected = "College Grad")
```

2. Filter for chosen education level(s) and save as a new (reactive) expression

```
# Server
# Create a subset of data filtering for chosen educ
NHANES_subset <- reactive({
  req(input$education)
  filter(NHANES, title_type %in% input$education)
})
```

Creates a **cached expression** that knows it is out of date when input changes

3. Use new data frame (which is reactive) for plotting

```
# Create the scatterplot object the plotOutput function is expecting
output$scatterplot <- renderPlot({
  ggplot(data = NHANES_subset(), aes_string(x =
                                            col
    geom_point(…) +
    …
})
```

Cached - only re-run when inputs change

4. Use new data frame (which is reactive) also for printing number of observations

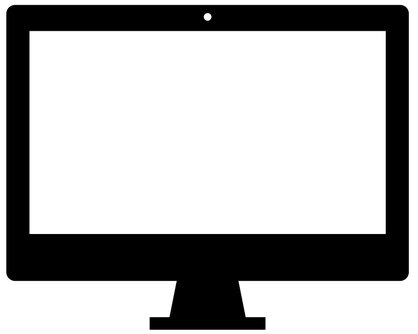
```
# UI
mainPanel(
  …
  # Print number of obs plotted
  uiOutput(outputId = "n"),
  …
  )
# Server
output$n <- renderUI({
  types <- NHANES_subset()$title_type %>%
    factor(levels = input$selected_type)
  counts <- table(types)

  HTML(paste("There are", counts, input$selected_type, “participants in this dataset.<br>"))
})
```

Putting it altogether

`nhanes-05.R`

Also notice

- HTML tags for visual separation
- `req()`



DEMO

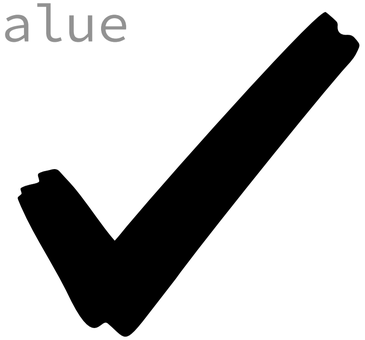
When to use reactives

- By using a reactive expression for the subsetted data frame, we were able to get away with subsetting once and then using the result twice
- In general, reactive conductors let you
  - not repeat yourself (i.e. avoid copy-and-paste code) which is a maintenance boon)
  - decompose large, complex (code-wise, not necessarily CPU-wise) calculations into smaller pieces to make them more understandable
- These benefits are similar to what happens when you decompose a large complex R script into a series of small functions that build on each other

Suppose we want to plot only a random sample of participants, of size determined by the user. What is wrong with the following?

```
# Server
# Create a new data frame that is a sample of n_samp
# observations from NHANES
NHANES_sample <- sample_n(NHANES_sample(), input$n_samp)

# Plot the sampled participants
output$scatterplot <- renderPlot({
  ggplot(data = NHANES_sample,
         aes_string(x = input$x, y = input$y,
                    color = input$z)) +
    geom_point(…)
})
```

```
# Server
# Create a new data frame that is a sample of n_samp
# observations from NHANES
NHANES_sample <- reactive({
  req(input$n_samp)      # ensure availability of value
  sample_n(NHANES_sample(), input$n_samp)
})

# Plot the sampled participants
output$scatterplot <- renderPlot({
  ggplot(data = NHANES_sample(),
         aes_string(x = input$x,
                    y = input$y,
                    color = input$z)) +
    geom_point(…)
})
```



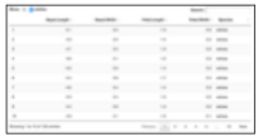
SOLUTION

Render functions

Render functions

```
render*({ [code_chunk] })
```

- Provide a code chunk that describes how an output should be populated
- The output will update in response to changes in any reactive values or reactive expressions that are used in the code chunk



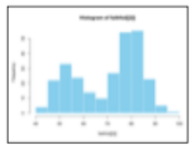
DT::**renderDataTable**(expr, options, callback, escape, env, quoted)

works with

dataTableOutput(outputId, icon, …)

renderImage(expr, env, quoted, deleteFile)

imageOutput(outputId, width, height, click, dblclick, hover, hoverDelay, hoverDelayType, brush, clickId, hoverId, inline)

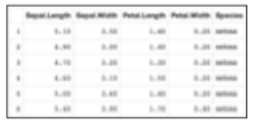


renderPlot(expr, width, height, res, …, env, quoted, func)

plotOutput(outputId, width, height, click, dblclick, hover, hoverDelay, hoverDelayType, brush, clickId, hoverId, inline)

renderPrint(expr, env, quoted, func, width)

verbatimTextOutput(outputId)



renderTable(expr,…, env, quoted, func)

tableOutput(outputId)

foo

renderText(expr, env, quoted, func)

textOutput(outputId, container, inline)

renderUI(expr, env, quoted, func)

uiOutput(outputId, inline, container, …)
& **htmlOutput**(outputId, inline, container, …)

Recap

```
render*({ [code_chunk] })
```

- These functions make objects to display
- Results should always be saved to `output$`
- They make an observer object that has a block of code associated with it
- The object will rerun the entire code block to update itself whenever it is invalidated

Implementation

Implementation of reactives

- **Reactive values** – `reactiveValues()`:
  - e.g. `input:` which looks like a list, and contains many individual reactive values that are set by input from the web browser
- **Reactive expressions** – `reactive()`: they depend on reactive values and observers depend on them
  - Can access reactive values or other reactive expressions, and they return a value
  - Useful for caching the results of any procedure that happens in response to user input
  - e.g. reactive data frame subsets we created earlier
- **Observers** – `observe()`: they depend on reactive expressions, but nothing else depends on them
  - Can access reactive sources and reactive expressions, but they don't return a value; they are used for their side effects
  - e.g. output object is a reactive observer, which also looks like a list, and contains many individual reactive observers that are created by using reactive values and expressions in reactive functions

Reactive expressions vs. observers

- Similarities: Both store expressions that can be executed
- Differences:
  - Reactive expressions return values, but observers don't
  - Observers (and endpoints in general) eagerly respond to reactives, but reactive expressions (and conductors in general) do not
  - Reactive expressions must not have side effects, while observers are only useful for their side effects

Your turn

Debug the following app scripts:

- `review/whats-wrong.R`
- `review/mult-3.R`
- `review/add-2.R`

5m 00s

Where to go next?

RStudio Community

rstudio::conf 2018

7 / week

4 unread

2 new

This category is for anything and everything related to rstudio::conf.

tidyverse

15 / week

6 new

This category is for anything and everything about the tidyverse.

RStudio IDE

21 / week

1 unread

7 new

This category is for discussing the RStudio IDE, both desktop and server versions.

Teaching

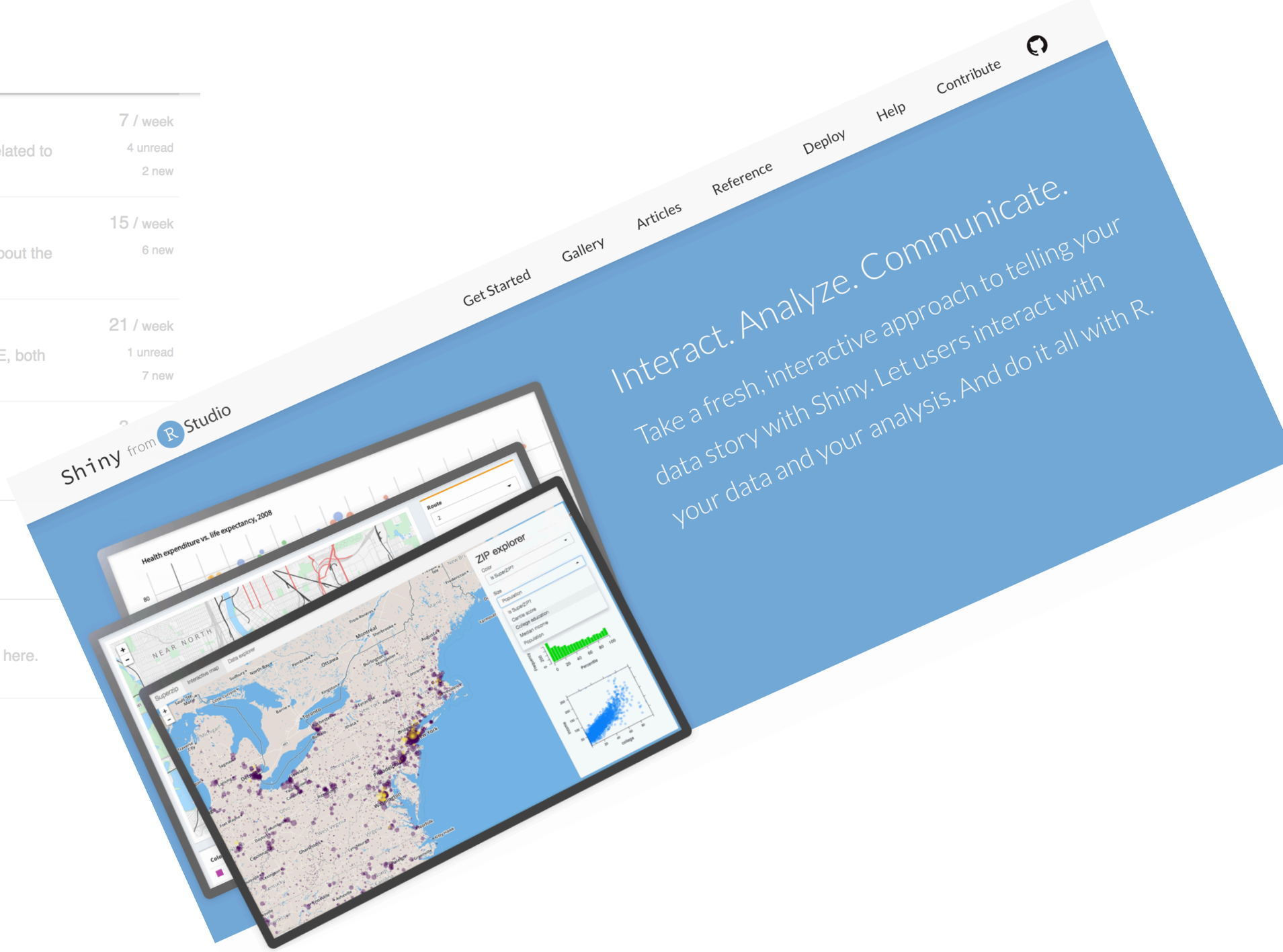
For discussions about teaching.

shiny

Please ask your questions about shiny here.

R Markdown

Please ask your questions about R Markdown here.



bit.ly/shiny-rlphl-git

Mine Çetinkaya-Rundel

@minebocek
mine-cetinkaya-rundel
mine@rstudio.com