

Automated Web Scraping with R

Resul Umit

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[I can teach this workshop at your institution — Email me.](#)

Who am I?

Resul Umit

- post-doctoral researcher in political science at the University of Oslo
- teaching and studying representation, elections, and parliaments
 - **a recent publication**: Parliamentary communication allowances do not increase electoral turnout or incumbents' vote share
- teaching workshops, also on
 - **writing reproducible research papers**
 - **version control and collaboration**
 - **working with Twitter data**
 - **creating academic websites**
- more information available at **resulumit.com**

The Workshop — Overview

- One and a half day, on how to automate the process of extracting data from websites
 - 160+ slides, 15+ exercises
 - a **demonstration website** for practice
- Designed for researchers with basic knowledge of R programming language
 - does not cover programming with R
 - e.g., we will use existing functions and packages
 - ability to work with R will be very helpful
 - but not absolutely necessary — this ability can be developed during and after the workshop as well

The Workshop — Motivation

- Data available on websites provide attractive opportunities for academic research
 - e.g., parliamentary websites were the main source of data for my PhD
- Acquiring such data requires
 - either a lot of resources, such as time
 - or a set of skills, such as automated web scraping
- Typically, such skills are not part of academic training
 - for my PhD, I visited close to 3000 webpages to collect data manually
 - on members of ten parliaments
 - multiple times, to update the dataset as needed

The Workshop — Motivation — Aims

- To provide you with an understanding of what is **ethically** possible
 - we will cover a large breath of issues, not all of it is for long-term memory
 - hence the slides are designed for self study as well
 - awareness of what is ethical and possible, Google, and perseverance are all you need
- To start you with acquiring and practicing the skills needed
 - practice with the demonstration website
 - plenty of data, stable structure, and an ethical playground
 - start working on a real project

The Workshop — Contents

Part 1. Getting the Tools Ready

- e.g., installing software

Part 2. Preliminary Considerations

- e.g., ethics of web scraping

Part 3. HTML Basics

- e.g., elements and attributes

Part 4. CSS Selectors

- e.g., selecting an element

Part 5. Scraping Static Pages

- e.g., getting text from an element

Part 6. Scraping Dynamic Pages

- e.g., clicking to create an element

[To the list of references.](#)

The Workshop — Organisation

- I will go through a number of slides...
 - introducing things
 - demonstrating how-to do things
- ... and then pause, for you to use/do those things
 - e.g., prepare your computer for the workshop, and/or
 - complete a number of exercises
- We are here to help
 - ask me, other participants
 - consult Google, **slides**, **answer script**
 - type, rather than copy and paste, the code you will find on the slides or the script

The Workshop — Organisation — Slides

03 : 00

Slides with this background colour indicate that your action is required, for

- setting the workshop up
 - e.g., installing R
- completing the exercises
 - e.g., checking website protocols
 - these slides have countdown timers
 - as a guide, not to be followed strictly

The Workshop — Organisation — Slides

- Code and text that go in R console or scripts appear as such – in a different font, on gray background
 - long codes and texts will have their own line(s)

```
bow(url = "https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "td+ td a") %>%  
  html_attr("href") %>%  
  url_absolute(base = "https://luzpar.netlify.app/")
```

The Workshop — Organisation — Slides

- Codes and texts that go in R console or scripts appear as such – in a different font, on gray background
 - long codes and texts will have their own line(s)
- Results that come out as output appear as such — in the same font, on green background
 - except for some results, such as a browser popping up
- Specific sections are highlighted yellow as such for emphasis
 - these could be for anything — codes and texts in input, results in output, and/or texts on slides
- The slides are designed for self-study as much as for the workshop
 - *accessible*, in substance and form, to go through on your own

Part 1. Getting the Tools Ready

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Workshop Slides — Access on Your Browser

- Having the workshop slides* on your own machine might be helpful
 - flexibility to go back and forward on your own
 - especially while in a breakout room
 - ability to scroll across long codes on some slides
- Access at https://resulunit.com/teaching/scrp_workshop.html
 - will remain accessible after the workshop
 - might crash for some Safari users
 - if using a different browser application is not an option, view the [PDF version of the slides](#) on GitHub

* These slides are produced in R, with the `xaringan` package ([Xie, 2021](#)).

Demonstration Website — Explore on Your Browser

05 : 00

- There is a demonstration website for this workshop
 - available at <https://luzpar.netlify.app/>
 - includes fabricated data on the imaginary Parliament of Luzland
 - provides us with plenty of data, stable structure, and an ethical playground
- Using this demonstration website for practice is recommended
 - tailored to exercises, no ethical concern
 - but not compulsory — use a different one if you prefer so
- Explore the website now
 - click on the links to see an individual page for
 - states, constituencies, members, and documents
 - notice that the documents section is different than the rest
 - it is a page with dynamic frame

Demonstration Website — Explore on Your Browser

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- Explore the website now
 - click on the links to see an individual page for
 - states, constituencies, members, and documents
 - notice that the documents section is different than the rest
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R — Download from the Internet and Install

- Programming language of this workshop
 - created for data analysis, extending for other purposes
 - e.g., accessing websites
 - allows for all three steps in one environment
 - accessing websites; scraping and processing data
 - an alternative: `python`
- Download R from <https://cloud.r-project.org>
 - optional, if you have it already installed — but then consider updating*
 - the `R.version.string` command checks the version of your copy
 - compare with the latest official release at <https://cran.r-project.org/sources.html>

* The same applies to all software that follows — consider updating if you have them already installed. This ensures everyone works with the latest, exactly the same, tools.

RStudio — Download from the Internet and Install

- Optional, but highly recommended
 - facilitates working with R
- A popular integrated development environment (IDE) for R
 - an alternative: **GNU Emacs**
- Download RStudio from <https://rstudio.com/products/rstudio/download>
 - choose the free version
 - to check for any updates, follow from the RStudio menu:

Help -> Check for Updates

RStudio Project — Create from within RStudio

- RStudio allows for dividing your work with R into separate projects
 - each project gets dedicated workspace, history, and source documents
 - [this page](#) has more information on why projects are recommended
- Create a new RStudio project for for this workshop, following from the RStudio menu:

```
File -> New Project -> New Directory -> New Project
```
- Choose a location for the project with Browse . . .
 - avoid choosing a synced location, e.g., Dropbox
 - likely to cause warning and/or error messages
 - if you must, pause syncing, or add an sync exclusion

R Packages — Install from within RStudio*

02:00

Install the packages that we need

```
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

* You may already have a copy of one or more of these packages. In that case, I recommend updating by re-installing them now.

R Packages — Install from within RStudio

Install the packages that we need

```
install.packages(c("rvest", "RSelenium", "robotstxt", "polite", "dplyr"))
```

We will use

- `rvest` ([Wickham, 2021](#)), for scraping websites
- `RSelenium` ([Harrison, 2020](#)), for browsing the web programmatically
- `robotstxt` ([Meissner and Ren, 2020](#)), for checking permissions to scrape websites
- `polite` ([Perepolkin, 2019](#)), for compliance with permissions to scrape websites
- `dplyr` ([Wickham, François, Henry, et al., 2022](#)), for data manipulation

R Script — Start Your Script

- Check that you are in the newly created project
 - indicated at the upper-right corner of RStudio window
- Create a new R Script, following from the RStudio menu

File -> New File -> R Script

- Name and save your file
 - to avoid the Untitled123 problem
 - e.g., scrape_web.R
- Load rvest and other packages

```
library(rvest)
library(RSelenium)
library(robotstxt)
library(polite)
library(dplyr)
```

Java — Download from the Internet and Install

- A language and software that RSelenium needs
 - for automation scripts
- Download Java from <https://www.java.com/en/download/>
 - requires restarting any browser that you might have open

Chrome — Download from the Internet and Install

- A browser that facilitates web scraping
 - favoured by R Selenium and most programmers
- Download Chrome from <https://www.google.com/chrome/>

SelectorGadget — Add Extension to Browser

- An extension for Chrome
 - facilitates selecting what to scrape from a webpage
 - optional, but highly recommended
 - open source software
- Add the extension to your browser
 - search for it at <https://chrome.google.com/webstore/category/extensions>
 - if you cannot use Chrome, drag and drop this link to your bookmarks bar
- ScrapeMate is an alternative extension
 - for both Chrome and Firefox
 - on Firefox, search at <https://addons.mozilla.org/>

Solutions — Note Where They Are

- Solutions to exercises, or links to them, are available online
 - can be downloaded at <https://luzpar.netlify.app/exercises/solutions.R>
- I recommend the solutions to be consulted as a last resort
 - after a genuine effort to complete the exercises yourself first

Other Resources*

- R Selenium vignettes
 - available at <https://cran.r-project.org/web/packages/R Selenium/vignettes/basics.html>
- R for Data Science (Wickham and Grolemund, 2021)
 - open access at <https://r4ds.had.co.nz>
- Text Mining with R: A Tidy Approach (Silge and Robinson, 2017)
 - open access at tidytextmining.com
 - comes with a [course website](#) where you can practice

* I recommend these to be consulted not during but after the workshop.

Part 2. Preliminary Considerations

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Considerations — the Law

- Web scraping might be illegal
 - depending on who is scraping what, why, how — and under which jurisdiction
 - reflect, and check, before you scrape
- Web scraping might be more likely to be illegal if, for example,
 - it is harmful to the source commercially and/or physically
 - e.g., scraping a commercial website to create a rival website
 - e.g., scraping a website so hard and fast that it collapses
 - it gathers data that is
 - under copyright
 - not meant for the public to see
 - then used for financial gain

Considerations — the Ethics

- Web scraping might be unethical
 - depending on who is scraping what, why, and how
 - reflect before you scrape
- Web scraping might be more likely to be unethical if, for example,
 - it is — edging towards — being illegal
 - it does not respect the restrictions
 - as defined in `robots.txt` files
 - it harvests data
 - that is otherwise available to download, e.g., through APIs
 - without purpose, at dangerous speed, repeatedly

Considerations — the Ethics — robots.txt

- Most websites declare a robots exclusion protocol
 - making their rules known with respect to programmatic access
 - who is (not) allowed to scrape what, and sometimes, at what speed
 - within robots.txt files
 - available at, e.g., www.websiteurl.com/robots.txt
- The rules in robots.txt cannot not enforced upon scrapers
 - but should be respected for ethical reasons
- The language in robots.txt files is specific but intuitive
 - easy to read and understand
 - the robotstxt package makes these even easier

Considerations — the Ethics — robots.txt — Syntax

- It has pre-defined keys, most importantly
 - User-agent indicates who the protocol is for
 - Allow indicates which part(s) of the website can be scraped
 - Disallow indicates which part(s) must not be scraped
 - Crawl-delay indicates how fast the website could be scraped
- In case you write your own protocol one day, note that
 - the keys start with capital letters
 - they are followed by a colon :

```
User-agent:  
Allow:  
Disallow:  
Crawl-delay:
```

Considerations — the Ethics — robots.txt — Syntax

- Websites define their own values
 - after a colon and a white space
- Note that
 - * indicates the protocol is for everyone
 - / indicates all sections and pages
 - /about/ indicates a specific path
 - values for Crawl-delay are in seconds
 - this website allows anyone to scrape, provided that
 - /about/ is left out, and
 - the website is accessed at 5-seconds intervals

```
User-agent: *  
Allow: /  
Disallow: /about/  
Crawl-delay: 5
```

Considerations — the Ethics — robots.txt — Syntax

Files might include optional comments, written after the number sign #

```
# thank you for respecting our protocol
```

```
User-agent: *
```

```
Allow: /
```

```
Disallow: /about/
```

```
Crawl-delay: 5 # please delay for five seconds, to ensure our servers are not overloaded
```


Considerations — the Ethics — robots.txt — Syntax

The protocol of this website only applies to Google

- Google is allowed to scrape everything
- there is no defined rule for anyone else

```
User-agent: googlebot  
Allow: /
```

Considerations — the Ethics — robots.txt — Syntax

The protocol of this website only applies to Google

- Google is **disallowed** to scrape **two** specific paths
 - with no limit on speed
- there is no defined rule for anyone else

```
User-agent: googlebot  
Disallow: /about/  
Disallow: /history/
```

Considerations — the Ethics — robots.txt — Syntax

This website has different protocols for different agents

- Google is allowed to scrape everything, with a 5-second delay
- Bing is not allowed to scrape anything
- everyone else can scrape the section or page located at www.websiteurl/about/

```
User-agent: googlebot
```

```
Allow: /
```

```
Crawl-delay: 5
```

```
User-agent: bing
```

```
Disallow: /
```

```
User-agent: *
```

```
Allow: /about/
```

Considerations — the Ethics — robots.txt

- The robots.txt package facilitates checking website protocols
 - from within R — no need to visit websites via browser
 - provides functions to check, among others, the rules for specific paths and/or agents
- There are two main functions
 - robots.txt, which gets complete protocols
 - paths_allowed, which checks protocols for one or more specific paths

Considerations — the Ethics — robots.txt

Use the `robots.txt` function to get a protocol

- supply a base URL with the `domain` argument
 - as a string
 - probably the only argument that you will need

```
robots.txt(  
    domain = NULL,  
    ...  
)
```

Considerations — the Ethics — robots.txt

```
robotstxt(domain = "https://luzpar.netlify.app")
```

```
## $domain
## [1] "https://luzpar.netlify.app"
##
## $text
## [robots.txt]
## -----
##
## User-agent: googlebot
## Disallow: /states/
##
## User-agent: *
## Disallow: /exercises/
##
## User-agent: *
## Allow: /
## Crawl-delay: 2
##
##
##
```

Considerations — the Ethics — robots.txt

Check the list of permissions for the most relevant part in the output

```
robotstxt(domain = "https://luzpar.netlify.app")$permissions
```

```
##      field useragent      value
## 1 Disallow googlebot    /states/
## 2 Disallow      *    /exercises/
## 3   Allow      *          /
```

Considerations — the Ethics — robots.txt

Use the `paths_allowed` function to check protocols for one or more specific paths

- supply a base URL with the `domain` argument
- `path` and `bot` are the other important arguments
 - notice the default values
- leads to either `TRUE` (allowed to scrape) or `FALSE` (not allowed)

```
paths_allowed(  
  domain = "auto",  
  paths = "/",  
  bot = "*",  
  ...  
)
```


Considerations — the Ethics — robots.txt

```
paths_allowed(domain = "https://luzpar.netlify.app")
```

```
## [1] TRUE
```

```
paths_allowed(domain = "https://luzpar.netlify.app",  
              paths = c("/states/", "/constituencies/"))
```

```
## [1] TRUE TRUE
```

```
paths_allowed(domain = "https://luzpar.netlify.app",  
              paths = c("/states/", "/constituencies/"), bot = "googlebot")
```

```
## [1] FALSE TRUE
```

Exercises

07:30

1) Check the protocols for <https://www.theguardian.com>

- via (a) your browser and (b) with the `robotstxt` function in R
- compare what you see

2) Check a path with the `paths_allowed` function

- such that it will return `FALSE`
- taking the information from Exercise 1 into account
- hint: try looking at the list of permissions first

3) Check the protocols for any website that you might wish to scrape

- with the `robotstxt` function
- reflect on the ethics of scraping that website

Considerations — the Ethics — Speed

- Websites are designed for visitors with human-speed in mind
 - computer-speed visits can overload servers, depending on bandwidth
 - popular websites might have more bandwidth
 - but, they might attract multiple scrapers at the same time
- Waiting a little between two visits makes scraping more ethical
 - waiting time may or may not be defined in the protocol
 - lookout for, and respect, the `Crawl-delay` key in `robots.txt`
 - [Part 5](#) and [Part 6](#) covers how to wait
- Not waiting enough might lead to a ban
 - by site owners, administrators
 - for IP addresses with undesirably high number of visits in a short period of time

Considerations — the Ethics — Purpose

Ideally, we scrape for a purpose

- e.g., for academics, to answer one or more research questions, test hypotheses
 - developed prior to data collection, analysis
 - based on, e.g., theory, claims, observations
 - perhaps, even pre-registered
 - e.g., at [OSF Registries](#)

Considerations — Data Storage

Scraped data frequently requires

- large amounts of digital storage space
 - internet data is typically big data
- private, safe storage spaces
 - due to local rules, institutional requirements

Part 3. HTML Basics

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HTML — Overview

- Webpages include more than what is immediately visible to visitors
 - not only text, images, links
 - but also code for structure, style, and functionality — interpreted by browsers first
 - HTML provides the structure
 - CSS provides the style
 - JavaScript provides functionality, if any
- Web scraping requires working with the source code
 - even when scraping only what is already visible
 - to choose one or more desired parts of the visible
 - e.g., text in table and/or bold only
- Source code also offers more, invisible, data to be scraped
 - e.g., URLs hidden under text

HTML — Webpage Source

The `Ctrl + U` shortcut is to display source code — alternatively, right click and View Page Source

HTML — DOM

Browsers also offer putting source codes in a structure

- known as DOM (document object model), initiated by the F12 key on Chrome

Exercises

05:00

4) View the source code of a page

- as plain code and as in DOM
- compare the look of the two

5) Search for a word or a phrase in source code

- copy from the front-end page
- search in plain text code or in DOM
 - using the `Ctrl + F` shortcut
- compare the look of the front- and back-end

HTML — Overview

- HTML stands for **hypertext markup language**
 - it gives the structure to what is visible to visitors
 - text, images, links
 - would a piece of text appear in a paragraph or a list?
 - depends on the HTML code around that text

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a declaration
 - so that browsers know what they are

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

HTML documents

- start with a declaration
 - so that browsers know what they are
- consist of **elements**
 - written in between opening and closing tags

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Root

`html` is the root element

- it is also the parent to all other elements
- its important children are the head and body elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — the Head

head contains metadata, such as

- titles, which appear in browser bars and tabs
- style elements

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

HTML — Overview

body contains the elements in the main body of pages, such as

- headers, paragraphs, lists, tables, images

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color: blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```


HTML — Syntax — Elements — Tags

Most elements have opening and closing tags

```
<p>This is a one sentence paragraph.</p>
```

This is a one sentence paragraph.

Note that

- tag name, in this case **p**, defines the structure of the element
- the closing tag has a forward slash **/** before the element name

HTML — Syntax — Elements — Content

Most elements have some **content**

```
<p>This is a one sentence paragraph.</p>
```

This is a one sentence paragraph.

HTML — Syntax — Elements — Attributes

Elements can have **attributes**

```
<p>This is a <strong id="sentence-count">one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- the `id` attribute is not visible to the visitors
- attribute string `sentence-count` could have been anything I could come up with
 - unlike the tag and attribute names — e.g., `strong`, `id` as they are pre-defined
- some other attributes, such as `style`, can have visible effects

HTML — Syntax — Elements — Attributes

There could be more than one attribute in a single element

```
<p>This is a <strong class="count" id="sentence-count">one</strong> sentence paragraph.</p>  
<p>There are now <strong class="count" id="paragraph-count">two</strong> paragraphs.</p>
```

This is a **one** sentence paragraph.

There are now **two** paragraphs.

Note that

- there could be more than one attribute in an element
 - with a white space in between them
- the same class attribute (e.i., count) can apply to multiple elements
 - while the id attribute must be unique on a page

HTML — Important Elements — Links

Links are provided with the a (anchor) element

```
<p>Click <a href="https://www.google.com/">here</a> to google things.</p>
```

Click [here](https://www.google.com/) to google things.

Note that

- href (hypertext reference) is a **required attribute** for this element
- most attributes are optional, but some are required

HTML — Important Elements — Links

Links can have titles

```
<p>Click <a title="This text appears when visitors hover over the link"
href="https://www.google.com/">here</a> to google things.</p>
```

Click [here](https://www.google.com/) to google things.

Note that

- the `title` attribute is one of the optional attributes
- it becomes visible when hovered over with mouse

HTML — Important Elements — Lists

The `` tag introduces un-ordered lists, while the `` tag defines lists items

```
<ul>
  <li>books</li>
  <li>journal articles</li>
  <li>reports</li>
</ul>
```

- books
- journal articles
- reports

Note that

- Ordered lists are introduced with the `` tag instead

HTML — Syntax — Notes

Elements can be nested

```
<p>This is a <strong>one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Note that

- there are two elements above, a paragraph and a strong emphasis
- strong is said to be the child of the paragraph element
 - there could be more than one child
 - in that case, children are numbered from the left
- paragraph is said to be the parent of the strong element

HTML — Syntax — Notes

By default, multiple spaces and/or lines breaks are ignored by browsers

```
<ul><li>books</li><li>journal  
</li>  
  
articles</li><li>reports  
  
</ul>
```

- books
- journal articles
- reports

Note that

- plain source code may or may not be written in a readable manner
- this is one reason why DOM is helpful

Exercises

10:00

6) Re-create the page at <https://luzpar.netlify.app/states/> in R

- start an HTML file, following from the RStudio menu:

```
File -> New File -> HTML File
```

- copy the text from the website, paste in the HTML file
- add the structure with HTML code
- click Preview to view the result

7) Add at least one extra tag and/or attribute

- with a visible effect on how the page looks at the front end
 - hints:
 - google if you need to
 - www.w3schools.com has a lot resources
- save this document as we will continue working on it

Part 3. CSS Selectors

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CSS — Overview

- CSS stands for **cascading stylesheets**
 - it gives the style to what is visible to visitors
 - text, images, links
 - would a piece of text appear in black or blue?
 - depends on the CSS for that text
- CSS can be defined
 - inline, as an attribute of an element
 - internally, as a child element of the head element
 - externally, but then linked in the head element

CSS — Syntax

- CSS is written in rules

```
p {font-size:12px;}
```

```
.count {background-color:yellow;}
```

```
#sentence-count {color:red;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more **selectors**, matching one or more HTML elements and/or attributes
- Note that
 - the syntax changes with the selector type
 - elements and attributes
 - among attributes, classes and ids

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:14px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors, matching one or more HTML elements and/or attributes
 - a **declaration**
- Note that
 - declarations are written in between two curly brackets

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:14px;}
```

CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors, matching one or more HTML elements and/or attributes
 - a declaration, with one or more **properties**
- Note that
 - properties are followed by a colon

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:14px;}
```


CSS — Syntax

- CSS is written in rules, with a syntax consisting of
 - one or more selectors
 - a declaration, with one or more properties and values
- Note that
 - values are followed by a semicolon
 - property:value; pairs are separated by a white space

```
p {font-size:14px;}  
h1 h2 {color:blue;}  
.count {background-color:yellow;}  
#sentence-count {color:red; font-size:14px;}
```

CSS — Internal

- CSS rules can be defined internally
 - within the `style` element
 - as a child of the `head` element
- Internally defined rules apply to all matching selectors
 - on the same page

```
<!DOCTYPE html>
<html>
  <head>
    <style>
      h1 {color:blue;}
    </style>
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

CSS — External

- CSS rules can be defined externally
 - saved somewhere linkable
 - defined with the the linked element
 - as a child of the head element
- Externally defined rules
 - are saved in a file with .css extension
 - apply to all matching selectors
 - on any page linked

```
<!DOCTYPE html>
<html>
  <head>
    <link rel="styles" href="simple.css">
    <title>A title for browsers</title>
  </head>
  <body>
    <h1>A header</h1>
    <p>This is a paragraph.</p>
    <ul>
      <li>This</li>
      <li>is a</li>
      <li>list</li>
    </ul>
  </body>
</html>
```

CSS — Inline

CSS rules can also be defined inline

- with the `style` attribute
- does not require selector
- applies only to that element

```
<p>This is a <strong style="color:blue;">one</strong> sentence paragraph.</p>
```

This is a **one** sentence paragraph.

Exercise

05:00

8) Provide some simple style to your HTML document

- one that you created during the previous exercise
- using internal or external style, but not inline
 - so that you can practice selecting elements
- no idea what to do? try
 - increasing the font size of the text in paragraph
 - change the colour of the second item in the list to red
 - get more ideas from www.w3schools.com/css

Part 5. Scraping Static Pages

[Back to the contents slide.](#)

Static Pages — Overview

- We will collect data from static pages with the `rvest` package
 - static pages are those that display the same source code to all visitors
 - including the content — it does not change
 - every visitor sees the same page at a given URL
 - each page has a different URL
 - <https://luzpar.netlify.app/> is a static page
- Scraping static pages involves two main tasks
 - download the source code from one or more pages to R
 - typically, the only interaction with the page itself
 - select the exact information needed from the source code
 - takes place locally, on your machine
 - the main functionality that `rvest` offers
 - with the help from selectors

Static Pages — `rvest` — Overview

- A relative small R package for web scraping
 - created by [Hadley Wickham](#)
 - popular — used by many for web scraping
 - downloaded 534,236 times last month
 - some of it must be thanks to being a part of the tidyverse family
 - last major revision was in March 2021
 - better alignment with tidyverse
- A lot has already been written on this package
 - you will find solutions to, or help for, any issues online
 - see first the [package documentation](#), numerous tutorials — such as [this](#), [this](#), and [this](#)
- Comes with the recommendation to combine it with the `polite` package
 - for ethical web scraping

Static Pages — rvest — Get Source Code

Use the `read_html` function to get the source code of a webpage into R

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">\n<meta charset
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="page-v
```

Static Pages — rvest — Get Source Code

You may wish to check the protocol first, for ethical scraping

```
paths_allowed(domain = "https://luzpar.netlify.app/")
```

```
## [1] TRUE
```

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}
## <html lang="en-us">
## [1] <head>\n<meta http-equiv="Content-Type" content="text/html; charset=UTF-8">\n<meta charset
## [2] <body id="top" data-spy="scroll" data-offset="70" data-target="#navbar-main" class="page-v
```

Static Pages — `rvest` — Get Source Code — `polite`

- The `polite` package facilitates ethical scraping
 - recommended by `rvest`
- It divides the process of getting source code into two
 - check the protocol
 - get the source only if allowed
- It also
 - waits for a period of time
 - minimum by what is specified in the protocol
 - allows you to introduce yourself to website administrators while scraping

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
 - for a specific `URL`

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    ...  
)
```

Static Pages — `rvest` — Get Source Code — `polite`

- First, use the `bow` function to check the protocol
 - for a specific URL
 - for a specific `agent`
- Note that
 - the `user_agent` argument can communicate information to website administrators
 - e.g., your name and contact details

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol

- for a specific URL
- for a specific agent
- for any **crawl-delay directives**

- Note that

- the delay argument cannot be set to a number smaller than in the directive
 - if there is one

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

Static Pages — rvest — Get Source Code — polite

- First, use the bow function to check the protocol

- for a specific URL
- for a specific agent
- for crawl-delay directives

```
bow(url,  
    user_agent = "polite R package - https://gi  
    delay = 5,  
    force = FALSE,  
    ...  
)
```

- Note that

- the delay argument cannot be set to a number smaller than in the directive
 - if there is one
- the force argument is set to FALSE by default
 - avoids repeated, unnecessary interactions with web page
 - by caching, and re-using, previously downloaded sources

Static Pages — rvest — Get Source Code — polite

- Second, use the `scrape` function get source code
 - for an object created with the `bow` function
- Note that
 - `scrape` will only work if the results from `bow` are positive
 - creating a safety valve for ethical scraping
 - by piping, `bow` into `scrape`, you can avoid creating objects

```
scrape(bow,  
      ...  
      )
```


Static Pages — rvest — Get Source Code

These two pieces of code lead to the same outcome, as there is no protocol against the access

```
read_html("https://luzpar.netlify.app/")
```

```
## {html_document}  
## <html lang="en-us">  
## [1] <head>\n<meta http-equiv="Content-Type  
## [2] <body id="top" data-spy="scroll" data-
```

```
bow(url = "https://luzpar.netlify.app/") %>%  
  scrape()
```

```
## {html_document}  
## <html lang="en-us">  
## [1] <head>\n<meta http-equiv="Content-Type  
## [2] <body id="top" data-spy="scroll" data-
```

Static Pages — rvest — Get Source Code

The difference occurs when there is a protocol against the access

```
read_html("https://luzpar.netlify.app/exercis
```

```
## {html_document}  
## <html>  
## [1] <head>\n<meta http-equiv="Content-Type  
## [2] <body>\r\n\r\n<h1>States of Luzland</h
```

```
bow(url = "https://luzpar.netlify.app/exercis  
scrape()
```

```
## NULL
```

Static Pages — rvest — html_elements

- Get one or more HTML elements
 - specified with a selector
 - CSS or XPATH
 - we will work with CSS in this workshop
 - facilitated by Chrome and SelectorGadget
- Note that
 - there are two versions of the same function
 - singular one gets the first instance of an element
 - plural one gets all instances

```
html_element(x,  
             css,  
             xpath)  
  
html_elements(x,  
             css,  
             xpath)
```

Static Pages — rvest — html_elements

Get the a (anchor) elements on the homepage

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "a")
```

```
## {xml_nodeset (24)}  
## [1] <a class="js-search" href="#" aria-label="Close"><i class="fas fa-times-circle text-muted"  
## [2] <a class="navbar-brand" href="/">Parliament of Luzland</a>  
## [3] <a class="navbar-brand" href="/">Parliament of Luzland</a>  
## [4] <a class="nav-link active" href="/"><span>Home</span></a>  
## [5] <a class="nav-link" href="/states/"><span>States</span></a>  
## [6] <a class="nav-link" href="/constituencies/"><span>Constituencies</span></a>  
## [7] <a class="nav-link" href="/members/"><span>Members</span></a>  
## [8] <a class="nav-link" href="/documents/"><span>Documents</span></a>  
## [9] <a class="nav-link js-search" href="#" aria-label="Search"><i class="fas fa-search" aria-  
## [10] <a href="#" class="nav-link" data-toggle="dropdown" aria-haspopup="true" aria-label="Disp  
## [11] <a href="#" class="dropdown-item js-set-theme-light"><span>Light</span></a>  
## [12] <a href="#" class="dropdown-item js-set-theme-dark"><span>Dark</span></a>  
## [13] <a href="#" class="dropdown-item js-set-theme-auto"><span>Automatic</span></a>  
## [14] <a href="https://github.com/resulumit/scrp_workshop" target="_blank" rel="noopener">a wor  
## [15] <a href="https://resulumit.com/" target="_blank" rel="noopener">Resul Umit</a>
```

Static Pages — rvest — html_elements

I would like to get only the URLs on the main body of the page

- SelectorGadget tells me the correct selector is #title a

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a")
```

```
## {xml_nodeset (9)}  
## [1] <a href="https://github.com/resulmit/scrp_workshop" target="_blank" rel="noopener">a worl  
## [2] <a href="https://resulmit.com/" target="_blank" rel="noopener">Resul Umit</a>  
## [3] <a href="/documents/">documents</a>  
## [4] <a href="/constituencies/">constituencies</a>  
## [5] <a href="/members/">members</a>  
## [6] <a href="/states/">states</a>  
## [7] <a href="https://github.com/rstudio/blogdown" target="_blank" rel="noopener">Blogdown</a>  
## [8] <a href="https://gohugo.io/" target="_blank" rel="noopener">Hugo</a>  
## [9] <a href="https://github.com/wowchemy" target="_blank" rel="noopener">Wowchemy</a>
```

Static Pages — `rvest` — `html_text`

- Get the text content of one or more HTML elements
 - for the elements already chosen
 - with the `html_elements` function
 - this returns what is already visible to visitors
- Note that
 - there are two versions of the same function
 - `html_text` returns text with any space or line breaks around it
 - `html_text2` returns plain text

```
html_text(x, trim = FALSE)
```

```
html_text2(x, preserve_nbsp = FALSE)
```

Static Pages — rvest — html_text

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_text()
```

```
## [1] "a workshop on automated web scraping" "Resul Umit"      "documents"  
## [4] "constituencies"                      "members"         "states"  
## [7] "Blogdown"                            "Hugo"             "Wowchemy"
```

Static Pages — rvest — html_attr

- Get one or more attributes of one or more HTML elements
 - for the elements already chosen
 - with the `html_elements` function
 - attributes are specified with their name
 - not CSS or XPATH
- Note that
 - there are two versions of the same function
 - singular one gets a specified attribute
 - plural one gets all available attributes

```
html_attr(x, name, default = NA_character_)  
html_attrs(x)
```


Static Pages — rvest — html_attrs

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attrs()
```

```
## [[1]]  
##                href                target  
## "https://github.com/resulimit/scrp_workshop" "_blank"  
##                rel  
##                "noopener"  
##  
## [[2]]  
##                href                target                rel  
## "https://resulimit.com/"            "_blank"            "noopener"  
##  
## [[3]]  
##                href  
## "/documents/"  
##  
## [[4]]  
##                href
```

Static Pages — rvest — html_attr

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attr(name = "href")
```

```
## [1] "https://github.com/resulunit/scrp_workshop" "https://resulunit.com/"  
## [3] "/documents/"                               "/constituencies/"  
## [5] "/members/"                                 "/states/"  
## [7] "https://github.com/rstudio/blogdown"        "https://gohugo.io/"  
## [9] "https://github.com/wowchemy"
```

Note that

- some URLs are given relative to the base URL
 - e.g., /states/, which is actually <https://luzpar.netlify.app/states/>
 - you can complete them with the `url_absolute` function

Static Pages — rvest — url_absolute

Complete the relative URLs with the url_absolute function

```
bow(url = "https://luzpar.netlify.app") %>%  
  scrape() %>%  
  html_elements(css = "#title a") %>%  
  html_attr(name = "href") %>%  
  url_absolute(base = "https://luzpar.netlify.app")
```

```
## [1] "https://github.com/resulimit/scrp_workshop" "https://resulimit.com/"  
## [3] "https://luzpar.netlify.app/documents/"      "https://luzpar.netlify.app/constituencies/"  
## [5] "https://luzpar.netlify.app/members/"        "https://luzpar.netlify.app/states/"  
## [7] "https://github.com/rstudio/blogdown"        "https://gohugo.io/"  
## [9] "https://github.com/wowchemy"
```

Static Pages — rvest — html_table

Use the `html_table()` function to get the text content of table elements

```
bow(url = "https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "table") %>%  
  html_table()
```

```
## [[1]]  
## # A tibble: 100 x 3  
##   Member      Constituency Party  
##   <chr>      <chr>      <chr>  
## 1 Arthur Ali    Mühlshafen  Liberal  
## 2 Chris Antony  Benwerder   Labour  
## 3 Chloë Bakker  Steffisfelden Labour  
## 4 Rose Barnes  Dillon      Liberal  
## 5 Emilia Bauer  Kilnard     Green  
## 6 Wilma Baumann Granderry    Green  
## 7 Matteo Becker Enkmelo     Labour  
## 8 Patricia Bernard Gänsernten  Labour  
## 9 Lina Booth    Leonrau     Liberal
```

Static Pages — rvest

We can create the same tibble with `html_text`, which requires getting each variable separately to be merged

```
tibble(  
  "Member" = bow(url = "https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(1) a") %>%  
    html_text(),  
  
  "Constituency" = bow(url = "https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(2) a") %>%  
    html_text(),  
  
  "Party" = bow(url = "https://luzpar.netlify.app/members/") %>%  
    scrape() %>%  
    html_elements(css = "td:nth-child(3)") %>%  
    html_text()  
)
```

Static Pages — rvest

Keep the number of interactions with websites to minimum

- by saving the source code as an object, which could be used repeatedly

```
the_page <- bow(url = "https://luzpar.netlify.app/members/") %>%
  scrape()

tibble(
  "Member" = the_page %>%
    html_elements(css = "td:nth-child(1)") %>%
    html_text(),
  "Constituency" = the_page %>%
    html_elements(css = "td:nth-child(2)") %>%
    html_text(),
  "Party" = the_page %>%
    html_elements(css = "td:nth-child(3)") %>%
    html_text()
)
```

Exercise

15:00

9) Create a dataframe out of the table at <https://luzpar.netlify.app/members/>

- with as many variables as possible
- hints:
 - start with the code in the previous slide, and add new variables from attributes
 - the first two columns have important attributes
 - e.g., URLs for the pages for members and their constituencies
 - make these URLs absolute
 - see what other attributes are there to collect

Static Pages — Crawling — Overview

- Rarely a single page includes all variables that we need
 - instead, they are often scattered across different pages of a website
 - e.g., we might need data on election results — in addition to constituency names
- Web scraping then requires crawling across pages
 - using information found on one page, to go to the next
 - website design may or may not facilitate crawling
- We can write for loops to crawl
 - the speed of our code matters the most when we crawl
 - ethical concerns are higher

Static Pages — Crawling — Example

Task:

- I need data on the name and vote share of parties that came second in each constituency
- This data is available on constituency pages, but
 - there are too many such pages
 - e.g., <https://luzpar.netlify.app/constituencies/arford/>
 - I do not have the URL to these pages

Plan:

- Scrape <https://luzpar.netlify.app/members/> for URLs
- Write a for loop to
 - visit these pages one by one
 - collect and save the variables needed
 - write these variables into a list
 - turn the list into a dataframe

Static Pages — Crawling — Example

Scrape the page that has all URLs, for absolute URLs

```
the_links <- bow(url = "https://luzpar.netlify.app/members/") %>%  
  scrape() %>%  
  html_elements(css = "td+ td a") %>%  
  html_attr("href") %>%  
  url_absolute(base = "https://luzpar.netlify.app/")  
  
# check if it worked  
head(the_links)
```

```
## [1] "https://luzpar.netlify.app/constituencies/muhlshafen/"  
## [2] "https://luzpar.netlify.app/constituencies/benwerder/"  
## [3] "https://luzpar.netlify.app/constituencies/steffisfelden/"  
## [4] "https://luzpar.netlify.app/constituencies/dillon/"  
## [5] "https://luzpar.netlify.app/constituencies/kilnard/"  
## [6] "https://luzpar.netlify.app/constituencies/granderry/"
```

Static Pages — Crawling — Example

Create an empty list

```
temp_list <- list()

for (i in 1:length(the_links)) {
  the_page <- bow(the_links[i]) %>% scrape()
  temp_tibble <- tibble(
    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),
    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),
    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()
  )
  temp_list[[i]] <- temp_tibble
}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Start a for loop to iterate over the links one by one

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Get the source code for the next link

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Get the variables needed, put them in a tibble

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}
```

Static Pages — Crawling — Example

Add each tibble into the previously-created list

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```

Static Pages — Crawling — Example

Turn the list into a tibble

```
temp_list <- list()

for (i in 1:length(the_links)) {

  the_page <- bow(the_links[i]) %>% scrape()

  temp_tibble <- tibble(

    "constituency" = the_page %>% html_elements("#constituency") %>% html_text(),

    "second_party" = the_page %>% html_element("tr:nth-child(3) td:nth-child(1)") %>%
      html_text(),

    "vote_share" = the_page %>% html_elements("tr:nth-child(3) td:nth-child(3)") %>%
      html_text()

  )

  temp_list[[i]] <- temp_tibble

}

df <- as_tibble(do.call(rbind, temp_list))
```


Static Pages — Crawling — Example

Check the resulting dataset

```
head(df, 10)
```

```
## # A tibble: 100 x 3
##   constituency second_party vote_share
##   <chr>          <chr>          <chr>
## 1 Mühlshafen    Green            26.1%
## 2 Benwerder     Conservative    24.8%
## 3 Steffisfelden Green            25.7%
## 4 Dillon        Conservative    27%
## 5 Kilnard       Conservative    28.8%
## 6 Granderry     Labour          26.1%
## 7 Enkmelo       Liberal         26.8%
## 8 Gänsernten    Green           26.6%
## 9 Leonrau       Conservative    25%
## 10 Zotburg      Conservative    28.4%
## # ... with 90 more rows
```

Exercise

45 : 00

10) Crawl into members' personal pages to create a rich dataset

- with members being the unit of observation

Hints:

- see an example dataset at https://luzpar.netlify.app/files/exercises/static_data.csv
- start with the related code in the previous slides, and adopt it to your needs
- practice with 3 members until you are ready to run the loop for all
 - e.g., by replacing `1:length(the_links)` with `1:3` for the loop

Part 6. Scraping Dynamic Pages

[Back to the contents slide.](#)

Dynamic Pages — Overview

- Dynamic pages are ones that display custom content
 - different visitors might see different content on the same page
 - while the URL remains the same
 - depending on, for example, their own input
 - e.g., clicks, scrolls
 - <https://luzpar.netlify.app/documents/> is a page with a dynamic part
- Dynamic pages are more difficult than static pages to scrape
 - it involves three, instead of two, steps
 - we will have a new package, R Selenium, for the additional step

Dynamic Pages — Three Steps to Scrape

Scraping dynamic pages involves three main tasks

- **Create** the desired instance of the dynamic page
 - with the `RSelenium` package
 - e.g., by clicking, scrolling, filling in forms, from within R
- **Get** the source code into R
 - `RSelenium` downloads XML
 - `rvest` turns it into HTML
- **Extract** the exact information needed from the source code
 - as for static pages
 - with the `rvest` package

Dynamic Pages — Rseelenium — Overview

- A package that integrates **Selenium 2.0 WebDriver** into R
 - created by **John Harrison**
 - downloaded 4,515 times last month
 - last updated in February 2020
- A lot has already been written on this package
 - you will find solutions to, or help for, any issues online
 - see the **package documentation** and the **vignettes** for basic functionality
 - Google searches return code and tutorials in various languages
 - not only R but also Python, Java

Dynamic Pages — R Selenium — Overview

- The package involves more methods than functions
 - code look slightly unusual for R
 - as it follows the logic behind Selenium
- It allows interacting with two things — and it is crucial that we are aware of the difference
 - browsers on your computer
 - e.g., opening a browser and navigating to a page
 - elements on a webpage
 - e.g., opening and clicking on a drop-down menu

Interacting with Browsers

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R

```
rsDriver(port = 4567L,  
        browser = "chrome",  
        version = "latest",  
        chromever = "latest",  
        ...  
)
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R
- Note that the defaults can cause errors, such as
 - trying to start two servers from the same port

```
rsDriver(port = 4567L,  
        browser = "chrome",  
        version = "latest",  
        chromever = "latest",  
        ...  
)
```

Dynamic Pages — Browsers — Starting a Server

- Use the `rsDriver` function to start a server
 - so that you can control a web browser from within R
- Note that the defaults can cause errors, such as
 - trying to start two servers from the same port
 - any mismatch between the version and driver numbers

```
rsDriver(port = 4567L,  
        browser = "chrome",  
        version = "latest",  
        chromeversion = "latest",  
        ...  
)
```

Dynamic Pages — Browsers — Starting a Server

- The latest version of the driver is too new for my browser
 - I have to use an older version to make it work
 - after checking the available versions with the following code

```
binman::list_versions("chromedriver")
```

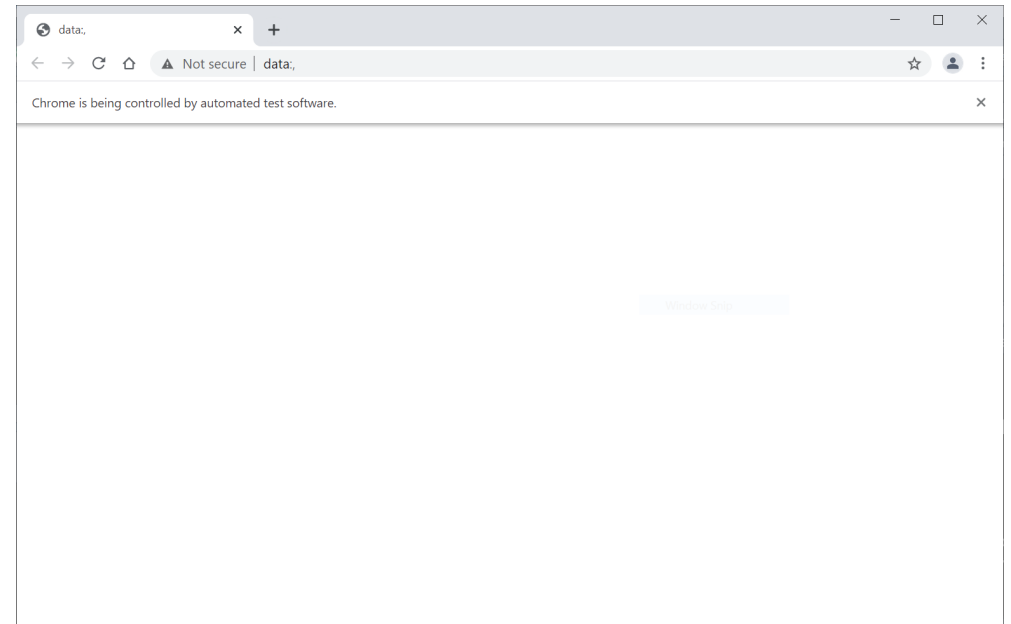
```
## $win32  
## [1] "98.0.4758.102" "99.0.4844.17"  "99.0.4844.35"
```

- Note that
 - you can only use the version that *you* have
 - you might have a different the version than the ones on this slide

Dynamic Pages — Browsers — Starting a Server

- Then the function works
 - a web browser opens as a result
 - an R object named `driver` is created
- Note that
 - the browser says "Chrome is being controlled by automated test software."
 - you should avoid controlling this browser manually
 - you should also avoid creating multiple servers

```
driver <- rsDriver(chromeversion = "98.0.4758.102")
```



Dynamic Pages — Browsers — Starting a Server

Separate the `client` and `server` as different objects

```
browser <- driver$client  
server <- driver$server
```

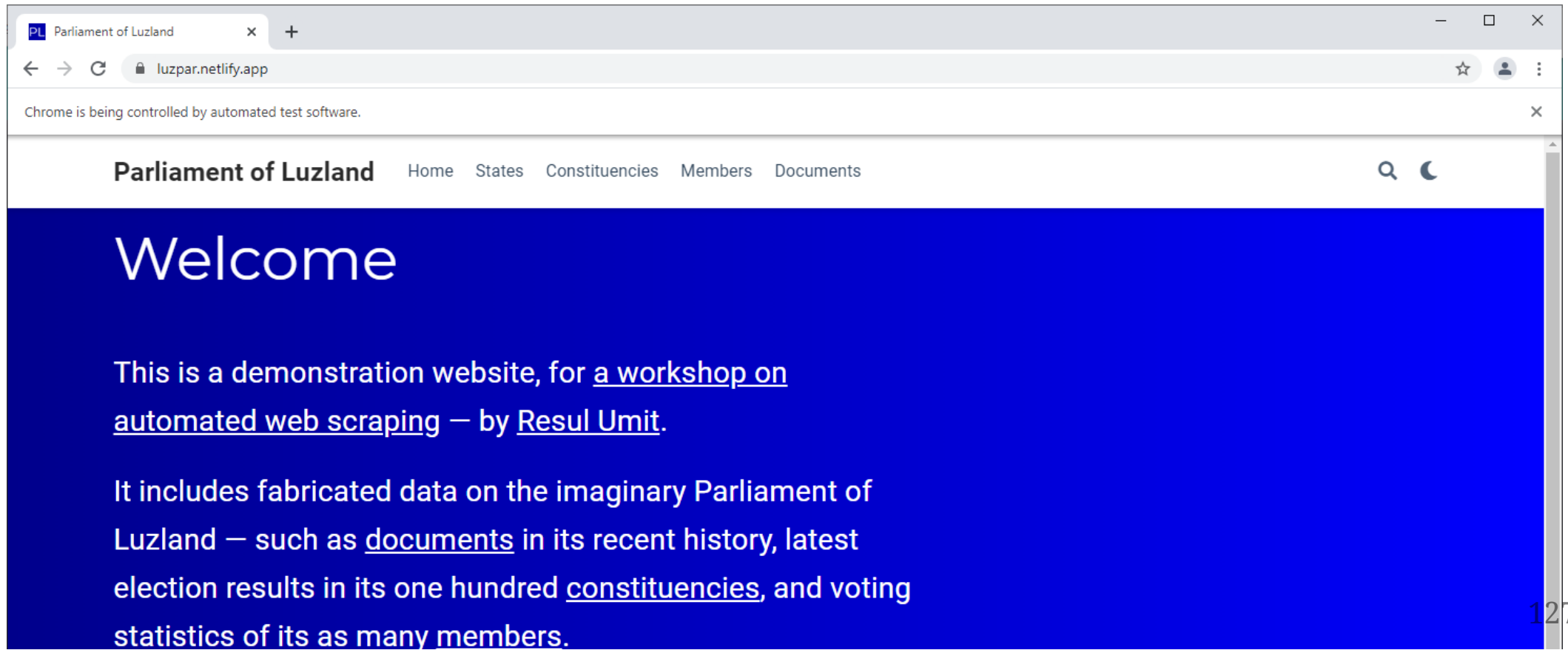
Note that

- `rsDriver()` creates a client and a server
 - the code above singles out the client, with which our code will interact
 - client is best thought as the browser itself
 - it has the class of `remoteDriver`

Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate(url = "https://luzpar.netlify.app")
```



Dynamic Pages — Browsers — Navigate

Navigate to a page with the following notation

```
browser$navigate("https://luzpar.netlify.app")
```

Note that

- navigate is called **a method, not a function**
 - it cannot be piped into browser
 - use the dollar sign **\$** notation instead
 - it is not necessary to type the name of the `url` argument

Dynamic Pages — Browsers — Navigate

Check the description of any method as follows

- with no parentheses after the method name

```
browser$navigate
```

```
Class method definition for method navigate()
function (url)
{
  "Navigate to a given url."
  qpath <- sprintf("%s/session/%s/url", serverURL, sessionInfo[["id"]])
  queryRD(qpath, "POST", qdata = list(url = url))
}
<environment: 0x00000173db9035a8>

Methods used:
  "queryRD"
```

Dynamic Pages — Browsers — Navigate

Go back to the previous URL

```
browser$goBack()
```

Go forward

```
browser$goForward()
```

Refresh the page

```
browser$refresh()
```

Dynamic Pages — Browsers — Navigate

Get the URL of the current page

```
browser$CurrentUrl()
```

Get the title of the current page

```
browser$getTitle()
```

Dynamic Pages — Browsers — Close and Open

Close the browser

- which will not close the session on the server
 - recall that we have singled the client out

```
browser$close()
```

Open a new browser

- which does not require the `rsDriver` function
 - because the server is still running

```
browser$open()
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

```
browser$getPageSource()[[1]]
```

Note that

- this method returns a list
 - XML source is in the first item
 - this is why we need the `[[1]]` bit
- this is akin to `read_html()` for static pages
 - or `bow() %>% scrape()`
- `rvest` usually takes over after this step

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by combining the two package

```
browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("#title a") %>%  
  html_attr("href")
```

```
[1] "https://github.com/resulumit/scrp_workshop"  
[2] "https://resulumit.com/"  
[3] "https://parliament-luzland.netlify.app/documents/"  
[4] "https://parliament-luzland.netlify.app/constituencies/"  
[5] "https://parliament-luzland.netlify.app/members/"  
[6] "https://parliament-luzland.netlify.app/states/"  
[7] "https://github.com/rstudio/blogdown"  
[8] "https://gohugo.io/"  
[9] "https://github.com/wowchemy"
```

Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

```
browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("#title a") %>%  
  html_attr("href")
```

Note that

- this method gets the source for only what is physically visible on the browser
- window size and position might become important
 - you may wish to maximise the window

```
browser$browser$maxWindowSize()
```


Dynamic Pages — Browsers — Get Page Source

Get the page source

- by using both packages

```
browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("#title a") %>%  
  html_attr("href")
```

Note that

- we still need the `read_html()` function
 - to turn XML into HTML

Exercises

15:00

11) Navigate to and get the source code of a page

- e.g., <https://luzpar.netlify.app/constituencies/>
- by using both packages

12) See what other methods are available to interact with browsers

- by typing the object name for your client into R console
 - followed by the dollar sign
 - and hitting the tab key on your keyboard if necessary
- read the description for one or more of them

13) Try one or more new methods

- e.g., take a screenshot of your browser
 - and view it in R

Interacting with Elements

Dynamic Pages — Elements — Find

- Locate an element on the open browser
 - to be interacted later on
 - e.g., clicking on the element
- Note that
 - the default selector is xpath
 - requires entering the xpath value

```
findElement(using = "xpath",  
            value  
            )
```

Dynamic Pages — Elements — Find

- Locate an element on the open browser
 - using CSS selectors
- Note that
 - typing "css", instead of "css selector", also works
 - there are other selector schemes as well, including
 - id
 - name
 - link text

```
findElement(using = "css selector",  
             value  
             )
```

Dynamic Pages — Elements — Find — Selectors

If there were a button on a page with the following DOM...

```
<button class="big-button" id="only-button" name="clickable">Click Me</button>
```

Any of the following would find it

```
browser$findElement(using = "xpath", value = '//*[@id = "only-button"]')  
browser$findElement(using = "css selector", value = ".big-button")  
browser$findElement(using = "css", value = "#only-button")  
browser$findElement(using = "id", value = "only-button")  
browser$findElement(using = "name", value = "clickable")
```

Dynamic Pages — Elements — Objects

Save elements as R objects to be interacted later on

```
button <- browser$findElement(using = ..., value = ...)
```

Note the difference between the classes of clients and elements

```
class(browser)
```

```
[1] "remoteDriver"  
attr(,"package")  
[1] "RSelenium"
```

```
class(button)
```

```
[1] "webElement"  
attr(,"package")  
[1] "RSelenium"
```

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page  
browser$navigate("http://luzpar.netlify.app/")  
  
# find the element  
menu_states <- browser$findElement(using = "link text", value = "States")  
  
# highlight it to see if we found the correct element  
menu_states$highlightElement()
```

Note that

- the highlighted element will flash for a second or two on the browser
 - helpful to check if selection worked as intended

Dynamic Pages — Elements — Highlight

Highlight the element found in the previous step, with the `highlightElement` method

```
# navigate to a page  
browser$navigate("http://luzpar.netlify.app/")  
  
# find the element  
menu_states <- browser$findElement(using = "link text", value = "States")  
  
# highlight it to see if we found the correct element  
`menu_states$`highlightElement()
```

Note that

- the highlighted element will flash for a second or two on the browser
 - helpful to check if selection worked as intended
- the highlight method is applied to the element (`menu_states`), not to the client (`browser`)
 - compare it to the find method

Dynamic Pages — Elements — Click

Click on the element found in the previous step, with the `clickElement` method

```
# navigate to a page  
browser$navigate("http://luzpar.netlify.app/")  
  
# find an element  
search_icon <- browser$findElement(using = "css", value = ".fa-search")  
  
# click on it  
search_icon$clickElement()
```

Dynamic Pages — Elements — Input

- Provide input to elements, such as
 - text, with the `value` argument

```
sendKeysToElement(list(value,  
                      key  
                      )  
                  )
```

Dynamic Pages — Elements — Input

- Provide input to elements, such as
 - text, with the value argument
 - keyboard presses or mouse gestures, with the **key** argument
- Note that
 - user provides values while the selenium keys are pre-defined

```
sendKeysToElement(list(value,  
                        key  
                        )  
)
```

Dynamic Pages — Elements — Input — Selenium Keys

View the list of Selenium keys

```
as_tibble(selKeys) %>% names()
```

```
## [1] "null"      "cancel"    "help"      "backspace" "tab"       "clear"
## [8] "enter"     "shift"     "control"   "alt"       "pause"     "escape"
## [15] "page_up"   "page_down" "end"       "home"      "left_arrow" "up_arrow"
## [22] "down_arrow" "insert"    "delete"    "semicolon" "equals"     "numpad_0"
## [29] "numpad_2"  "numpad_3"  "numpad_4"  "numpad_5"  "numpad_6"  "numpad_7"
## [36] "numpad_9"  "multiply"  "add"       "separator" "subtract"   "decimal"
## [43] "f1"       "f2"       "f3"       "f4"       "f5"       "f6"
## [50] "f8"       "f9"       "f10"      "f11"      "f12"      "command_meta"
```

Dynamic Pages — Elements — Input — Selenium Keys — Note

Choosing the body element, you can scroll up and down a page

```
body <- browser$findElement(using = "css", value = "body")  
body$sendKeysToElement(list(key = "page_down"))
```

Dynamic Pages — Elements — Input — Example

Search the demonstration site

```
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```

Dynamic Pages — Elements — Input — Example

Slow down the code where necessary, with the `Sys.sleep`

- for ethical reasons
- because R might be faster than the browser

```
# navigate to the home page
browser$navigate("http://luzpar.netlify.app/")

# find the search icon and click on it
search_icon <- browser$findElement(using = "css", value = ".fa-search")
search_icon$clickElement()

# sleep for 2 seconds
Sys.sleep(2)

# find the search bar on the new page and click on it
search_bar <- browser$findElement(using = "css", value = "#search-query")
search_bar$clickElement()

# search for the keyword "Law" and click enter
search_bar$sendKeysToElement(list(value = "Law", key = "enter"))
```


Dynamic Pages — Elements — Input — Clear

Clear text, or a value, from an element

```
search_bar$clearElement()
```

Exercise

10:00

14) Conduct an internet search programatically

- navigate to <https://duckduckgo.com/>
 - just to keep it simple as Google would require you to scroll down and accept a policy
- find, highlight, and fill in the search bar
 - hit enter

15) Scroll down programatically, and up

- to see all results

16) Go back, and conduct another search

- hint: you will have to find the search bar again

Dynamic Pages — Elements — Switch Frames

- Switch to a different frame on a page
 - some pages have multiple frames
 - you can think of them as browsers within browsers
 - while in one frame, we cannot work with the page source of another frame

```
switchToFrame(Id  
              )
```

- Note that
 - there is one such page on the demonstration website
 - <https://luzpar.netlify.app/documents/>
 - featuring a shiny app that lives originally lives at <https://resulumit.shinyapps.io/luzpar/>
 - the Id argument takes an element object, unquoted
 - setting it to NULL returns to the default frame

Dynamic Pages — Elements — Switch Frames

Switch to a non-default frame

```
# navigate to a page and wait for the frame to load
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# find the frame, which is an element
app_frame <- browser$findElement("css", "iframe")

# switch to it
browser$switchToFrame(Id = app_frame)

#switch back to the default frame
browser$switchToFrame(Id = NULL)
```

Dynamic Pages — Scraping — Example

Task:

- I need to download specific documents published by the parliament
 - e.g., proposals and reports
- The related section of the website is a dynamic page
 - initially it is empty, and clicking on things do not change the URL

Plan:

- Interact with the page until it displays the desired list of documents
- Get the page source and separate the links
- Write a for loop to
 - visit the related pages one by one
 - download the documents

Dynamic Pages — Scraping — Example

Interact with the page until it displays the desired list of documents

```
# navigate to the desired page and wait a little
browser$navigate("https://luzpar.netlify.app/documents/")
Sys.sleep(4)

# switch to the frame with the app
app_frame <- browser$findElement("css", "iframe")
browser$switchToFrame(Id = app_frame)

# find and open the drop down menu
drop_down <- browser$findElement(using = "css", value = ".bs-placeholder")
drop_down$clickElement()

# choose proposals
proposal <- browser$findElement(using = 'css', "[id='bs-select-1-1']")
proposal$clickElement()

# choose reports
report <- browser$findElement(using = 'css', "[id='bs-select-1-2']")
report$clickElement()

# close the drop down menu
drop_down$clickElement()
```

Dynamic Pages — Scraping — Example

Get the page source and separate the links

```
the_links <- browser$getPageSource()[[1]] %>%  
  read_html() %>%  
  html_elements("td a") %>%  
  html_attr("href")  
  
print(the_links)
```

```
## [1] "https://luzpar.netlify.app/documents/human-rights-2021/"  
## [2] "https://luzpar.netlify.app/documents/greenhouse-gas-emissions-2021/"  
## [3] "https://luzpar.netlify.app/documents/tax-reform-2020/"  
## [4] "https://luzpar.netlify.app/documents/parliamentary-staff-2020/"  
## [5] "https://luzpar.netlify.app/documents/cyber-security-2019/"  
## [6] "https://luzpar.netlify.app/documents/electronic-cigarettes-2019/"
```

Dynamic Pages — Scraping — Example

Write a for loop to download PDFs

```
for (i in 1:length(the_links)) {  
  pdf_link <- bow(url = the_links[i]) %>%  
    scrape() %>%  
    html_elements(css = ".btn-page-header") %>%  
    html_attr("href") %>%  
    url_absolute(base = "https://luzpar.netlify.app/")  
  
  download.file(url = pdf_link, destfile = basename(pdf_link))  
}
```


Exercise

30:00

17) Collect data on a subset of documents

- article tags and image credits
- for documents within the Law and Proposal categories
- published after 2019

References

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The workshop ends here.

Congratulations for making it this far, and
thank you for joining me!

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