Week 2: Quantifying Texts

POP77142 Quantitative Text Analysis for Social Scientists

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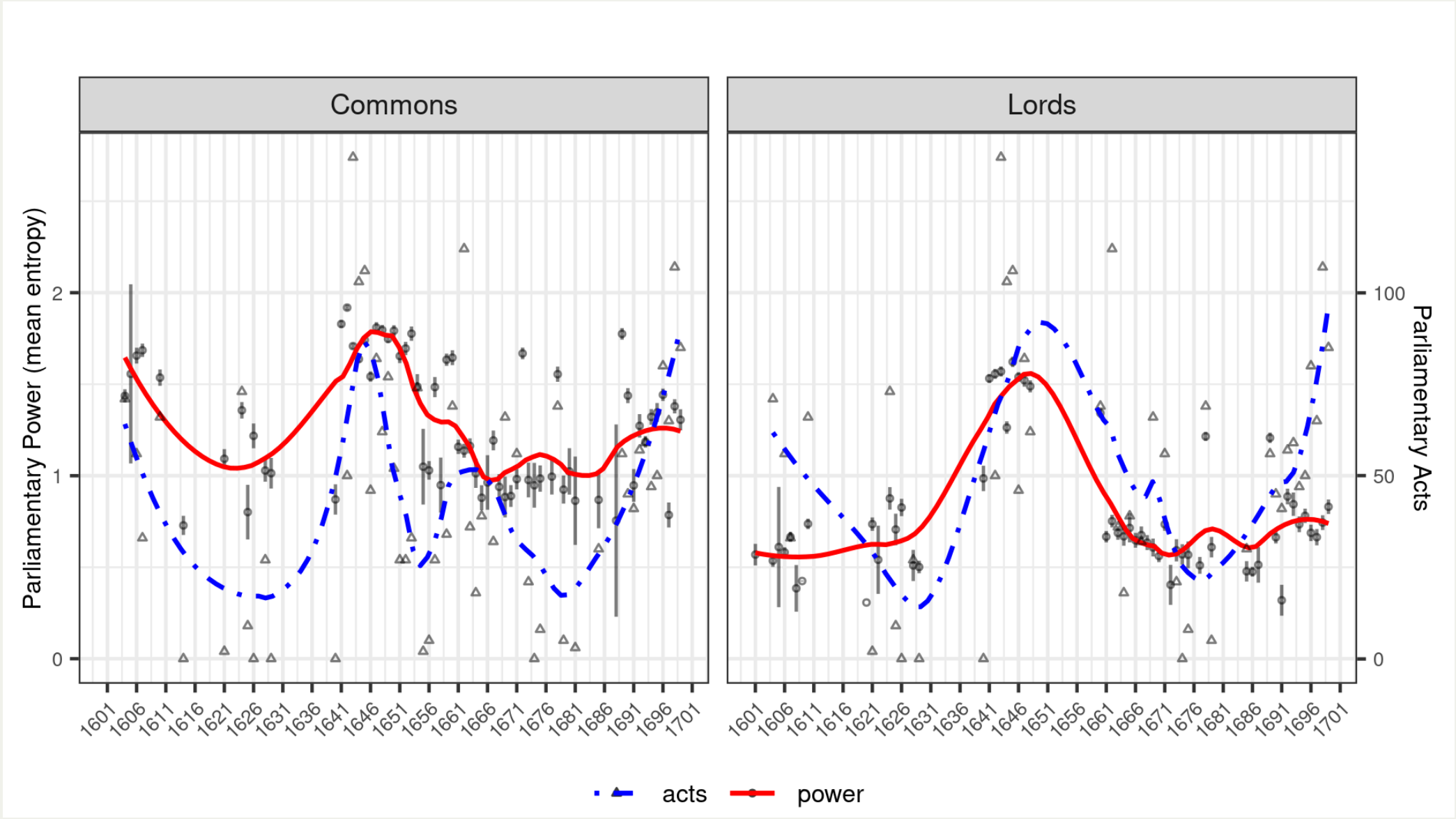
Overview

- Motivation
- Character Encoding
- Text Preprocessing
- APIs
- JSON

Motivation

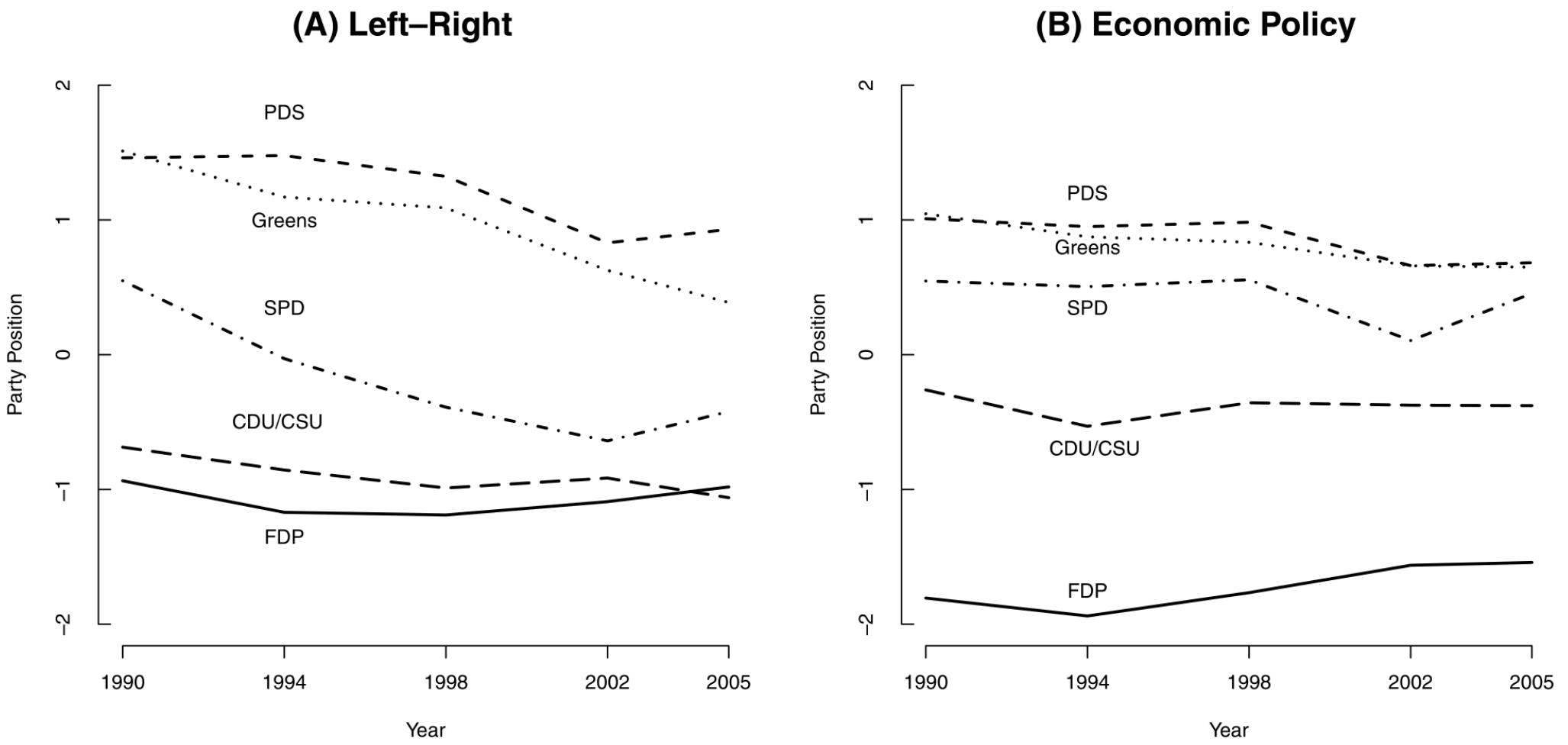
Parliamentary Power in 17th c. England



(Rodon & Paskhalis, 2024)

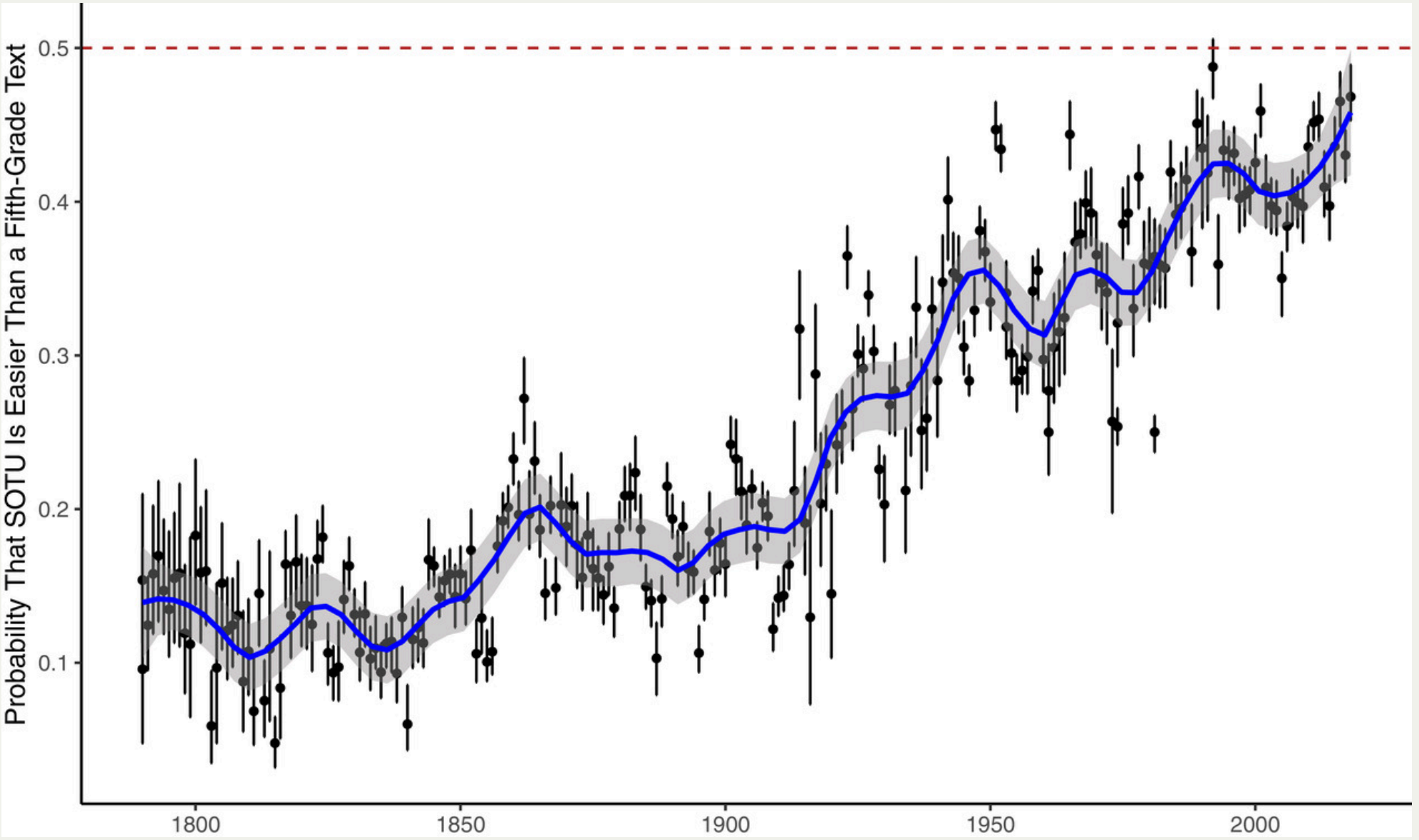
Ideological Positions in Germany

FIGURE 1 Estimated Party Positions in Germany, 1990–2005



(Slapin & Proksch, 2008)

Complexity of US State of the Union Addresses



(Benoit, Munger & Spirling, 2019)

Character Encoding

Foundations of Computer Memory

- Bits:
  - The smallest unit of digital data.
  - Can be either 0 or 1.
  - n bits can represent 2^n different values.
  - E.g. 2 bits can represent 4 values: 00, 01, 10, 11.
- Bytes:
  - 8 bits = 1 byte
  - Thus, 1 byte can represent 256 values: [00000000, 00000001, . . . , 11111111].
  - Metric aggregations than are kilobyte (KB), megabyte (MB), gigabyte (GB), etc.

Character Encoding

- **Character** - “the smallest component of written language that has semantic value” (https://unicode.org/glossary/#character).
  - E.g. “h”, “ε”, “4”, “&”, “!”, “€”, “🤖”.
- **Character set** - a collection of characters.
  - E.g. Latin alphabet, Greek alphabet, Arabic numerals, punctuation marks, etc.
- **Code point** - the unique value assigned to each character in a set.
  - Depends on what is a considered a valid value: binary - 101101, decimal - 45, hexadecimal - 2D, etc.
- A mapping between code points and characters is called an **encoding**.

ASCII

- **ASCII** (**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange) - one of the earlier wide-spread character encodings.
- Only encodes $2^7 = 128$ characters (of which 95 are printable).
  - Essentially, English alphabet, Arabic numerals, and some punctuation marks.
- Later extended to $2^8 = 256$ characters
  (aka **ISO-8859-1**, **Latin-1**, closely related to **Windows-1252**).
  - Added support for most Western European languages.
- A lot more needed to support all the world's languages…

ASCII

$b_7 b_6 b_5$ → / Bits b_4 b_3 b_2 b_1 ↓	Column → / Row ↓	000	001	010	011	100	101	110	111
		0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	\	l	¦
1 1 0 1	13	CR	GS	—	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

(Wikipedia & US DoD)

- E.g., decimal code point for “A” is 65, comprised of these bits:
  - 1000001 (original ASCII)
  - 01000001 (ISO-8859-1)

Unicode

- Designed to support all the world's writing systems that can be digitized.
- Variable-length, between 1 and 4 bytes (8 and 32 bits).
- First 128 code points are the same as in ASCII (backward compatibility).
- **UTF-8** - most common Unicode encoding (also **UTF-16**, but more rare):
  - 1 byte for ASCII characters.
  - 2 bytes for most Latin, Greek, Cyrillic, CJK, etc.
  - 3 bytes for the rest of the BMP.
  - 4 bytes for the rest of Unicode.

Digital Storage of Text

Plain Text & Binary Files

- **Plain text** files contain only human-readable characters.
  - "Simple" text, e.g. `.txt`
  - Markup languages, e.g. `.md`, `.Rmd`, `qmd`, `.html`
  - Data storage, e.g. `.csv`, `.tsv`, `.tab`, `.json`, `.xml`
  - Images, e.g. `.svg`, `.eps`
  - Computer code, e.g. `.py`, `.R`, `.tex`, `.sh`
  - Some other: `.ipynb` (effectively, `.json`), `.docx` (effectively, zipped `.xml`)
- **Binary** files contain computer-readable data (parts can be human-readable).
  - Text, e.g. `.doc`, `.rtf`, `.pdf`
  - Data storage, e.g. `.pickle`, `.rds`, `.feather`
  - Images, e.g. `.png`, `.jpg`, `.gif`
- Not always dichotomous (e.g. `.docx`, `.pdf`, `.svg`).

Text Encoding Caveats

- Plain text files don't contain information about encoding.
- Instead, each software "guesses" (often, assumes the default).
- If the guess is wrong, text can be displayed incorrectly (*mojibake*).
- UTF-8 is the most common encoding (the one you should use).
- However, many texts still use other encodings.
- Windows is often a problem (can use `Windows-1252` or `UTF-16`).
- In general, no easy way to know the encoding of a text file.

Text Encoding: Example

Write out text using Python in `ISO-8859-1` encoding.

```python
tain_bo_cualinge = "Fecht n-óen do Ailill & do Meidb íar ndérgud a rígleptha dóib i Crúachanráith Chonnacht,

with open("../temp/latin1.txt", "w", encoding = "ISO-8859-1") as f:
    f.write(tain_bo_cualinge)
```

```
130
```

Read in text in R using the default (`UTF-8`) encoding.

```r
tain_bo_cualinge <- readLines("../temp/latin1.txt")
tain_bo_cualinge
```

```
[1] "Fecht n-\xf3en do Ailill & do Meidb \xedar nd\xe9rgud a r\xedgleptha d\xf3ib i Cr\xfaachanr\xe1ith
Chonnacht, arrecaim comr\xe1d chind cherchailli eturru."
```

Using `ISO-8859-1` (note the difference in the encoding name).

```r
tain_bo_cualinge <- readLines("../temp/latin1.txt", encoding = "latin1")
tain_bo_cualinge
```

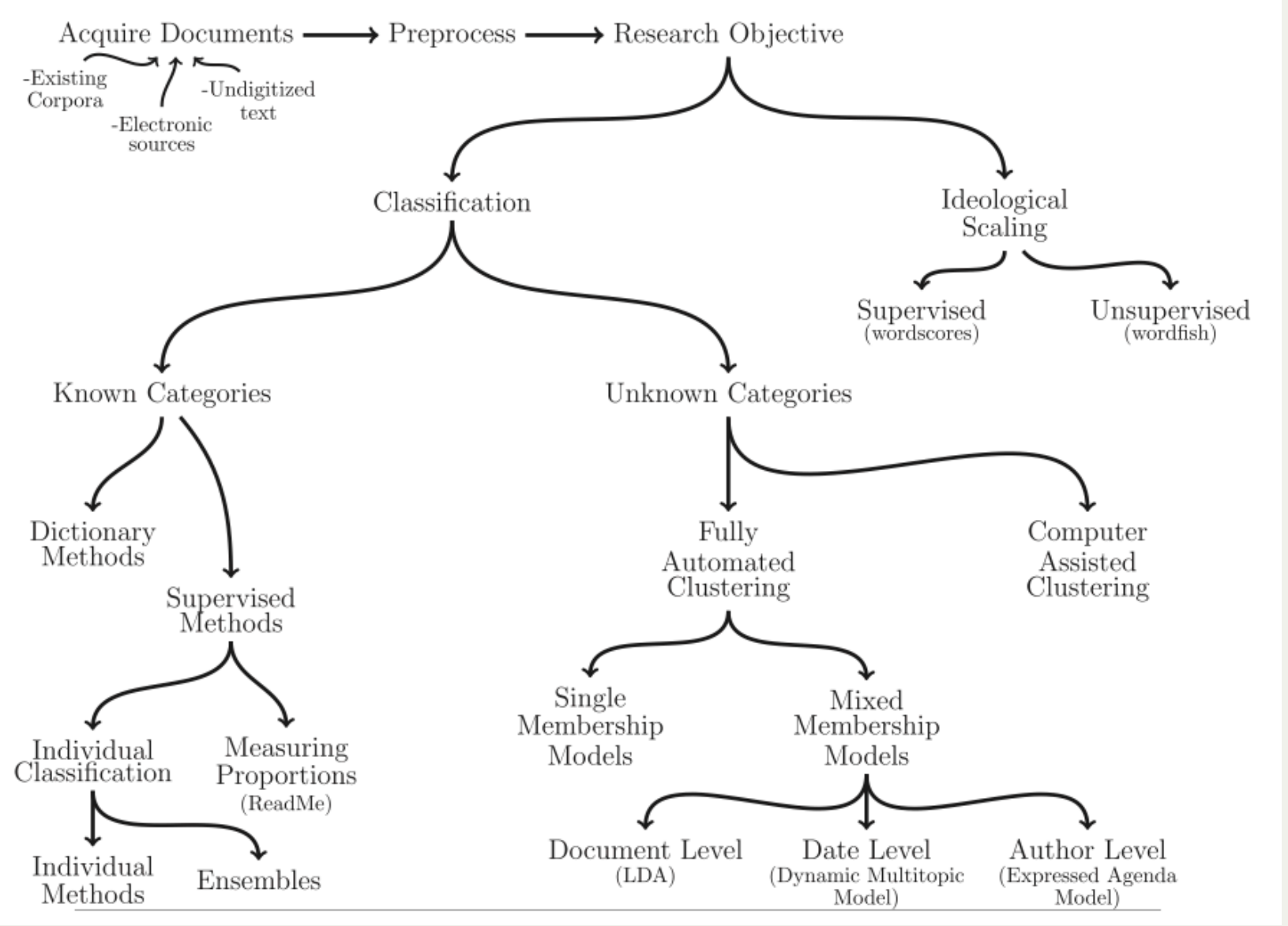
```
[1] "Fecht n-óen do Ailill & do Meidb íar ndérgud a rígleptha dóib i Crúachanráith Chonnacht, arrecaim comrád
chind cherchailli eturru."
```

Text Encoding: Things to Try

- Pick a movie you like.
- Go to OpenSubtitles.
- Find subtitles for that movie in a language that uses a different script.
- Download the subtitles and try to open them in a text editor.
- Check the ‘guessed’ encoding of the file.
- Are all characters displayed correctly?
- Try to open the file programmatically in R or Python.

Designing a Text Analysis Study

Workflow in Text Analysis



(Grimmer & Stewart, 2013)

Sample vs Population

- Basic Idea: Observed text is a stochastic realization.
- Systematic features shape most of observed verbal content.
- Non-systematic, random features also shape verbal content.

Implications of a Stochastic View

- Observed text is not the only text that could have been generated.
- Research (system) design would depend on the question and quantity of interest.
- Very different if you are trying to monitor something like hate speech, where what you actually say matters, not the value of your “expected statement”.
- Means that having “all the text” is still not a “population”.

Sampling Strategies

- Be clear what is you *sample* and your *population*.
- May not be feasible to perform any sampling.
- Different types of sampling vary from random to purposive:
  - Random sampling (e.g. politician's speeches)
  - Non-random sampling (e.g. messages containing hate speech on a social media platform)
- Key is to make sure that what is being analyzed is a valid representation of the phenomenon as a whole - a question of research design.

Text Preprocessing

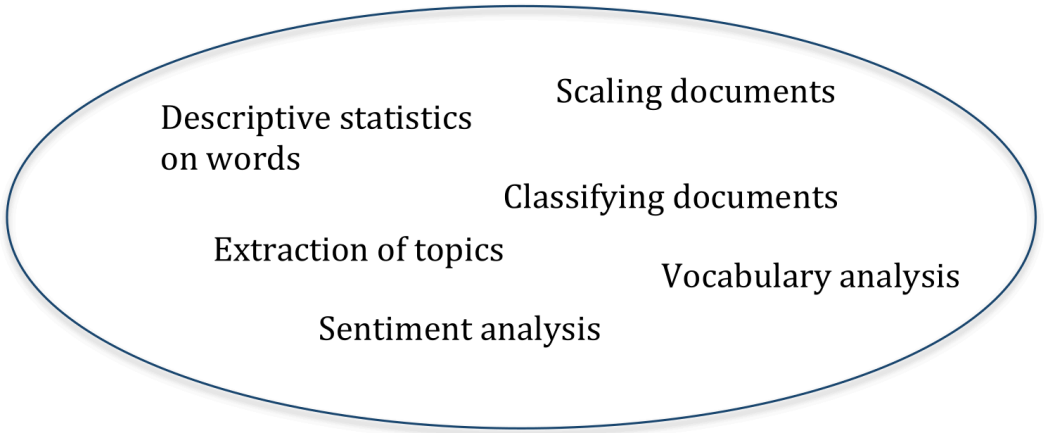
Quantifying Texts

When I presented the supplementary budget to this House last April, I said we could work our way through this period of severe economic distress. Today, I can report that notwithstanding the difficulties of the past eight months, we are now on the road to economic recovery.

In this next phase of the Government's plan we must stabilise the deficit in a fair way, safeguard those worst hit by the recession, and stimulate crucial sectors of our economy to sustain and create jobs. The worst is over.

This Government has the moral authority and the well-grounded optimism rather than the cynicism of the Opposition. It has the imagination to create the new jobs in energy, agriculture, transport and construction that this green budget will

	words										
docs	made	because	had	into	get	some	through	next	where	many	irish
t06_kenny_fg	12	11	5	4	8	4	3	4	5	7	10
t05_cowen_ff	9	4	8	5	5	5	14	13	4	9	8
t14_ocaolain_sf	3	3	3	4	7	3	7	2	3	5	6
t01_lenihan_ff	12	1	5	4	2	11	9	16	14	6	9
t11_gormley_green	0	0	0	3	0	2	0	3	1	1	2
t04_morgan_sf	11	8	7	15	8	19	6	5	3	6	6
t12_ryan_green	2	2	3	7	0	3	0	1	6	0	0
t10_quinn_lab	1	4	4	2	8	4	1	0	1	2	0
t07_odonnell_fg	5	4	2	1	5	0	1	1	0	3	0
t09_higgins_lab	2	2	5	4	0	1	0	0	2	0	0
t03_burton_lab	4	8	12	10	5	5	4	5	8	15	8
t13_cuffe_green	1	2	0	0	11	0	16	3	0	3	1
t08_gilmore_lab	4	8	7	4	3	6	4	5	1	2	11
t02_bruton_fg	1	10	6	4	4	3	0	6	16	5	3



Some QTA Terminology

- **Corpus** - a collection of texts for analysis.
  - E.g. SOTU addresses, Hansard debates, party manifestos, etc.
- **Document** - a single text in the corpus.
  - E.g. a single SOTU address, one speech, a specific party manifesto, etc.
- **Token** - a single unit of text.
  - E.g. typically a word, but can include punctuation, numbers, hashtags, etc.
- **Type** - a unique token.
  - E.g. articles like “the” and “a” appearing throughout the corpus.
- **Tokenization** - the process of breaking a text into tokens.

Some Linguistic Terminology

- Tokens constitute the basic unit of analysis (particularly in NLP applications).
- But how tokens are constructed can vary.
- It might be useful to consider different tokens as the same.
  - E.g. “runs”, “running”, “ran” are all forms of the same word.
- **Stemming** - mechanically removing affixes (usually, suffixes) from tokens.
  - E.g. “running” -> “run”, “runs” -> “run”.
- **Lemmatization** - reducing tokens to their base (root) or dictionary form.
  - E.g. “ran” -> “run”, “runner” -> “run”.
- While lemmatization is more accurate, it also requires more built-in knowledge about a language.

Tokenization: Example

```
library("quanteda")
```

```
text <- "The quick brown fox jumps over the lazy dog."
tokens <- quanteda::tokens(text)
tokens
```

```
Tokens consisting of 1 document.
text1 :
 [1] "The"   "quick" "brown" "fox"   "jumps" "over"  "the"   "lazy"  "dog"
[10] "."
```

```
quanteda::ntoken(tokens)
```

```
text1
   10
```

```
quanteda::ntype(tokens)
```

```
text1
   10
```

```
tokens <- quanteda::tokens_tolower(tokens)
quanteda::ntoken(tokens)
```

```
text1
   10
```

```
quanteda::ntype(tokens)
```

```
text1
    9
```

```
tokens_stemmed <- quanteda::tokens_wordstem(tokens, language = "english")
tokens_stemmed
```

```
Tokens consisting of 1 document.
text1 :
 [1] "the"   "quick" "brown" "fox"   "jump"  "over"  "the"   "lazi"  "dog"
[10] "."
```

Stopwords

- Not all words can be assumed to be equally informative.
- E.g. “the”, “a”, “and”, etc. are common in most texts.
- **Stopwords** are words that are removed from the text before analysis.

```
1 library("stopwords")
```

```
1 stopwords::stopwords(language = "en")
```

```
  [1] "i"          "me"         "my"         "myself"     "we"
  [6] "our"        "ours"       "ourselves"  "you"        "your"
 [11] "yours"      "yourself"   "yourselves" "he"         "him"
 [16] "his"        "himself"    "she"        "her"        "hers"
 [21] "herself"    "it"         "its"        "itself"     "they"
 [26] "them"       "their"      "theirs"     "themselves" "what"
 [31] "which"      "who"        "whom"       "this"       "that"
 [36] "these"      "those"      "am"         "is"         "are"
 [41] "was"        "were"       "be"         "been"       "being"
 [46] "have"       "has"        "had"        "having"     "do"
 [51] "does"       "did"        "doing"      "would"      "should"
 [56] "could"      "ought"      "i'm"        "you're"     "he's"
 [61] "she's"      "it's"       "we're"      "they're"    "i've"
 [66] "you've"     "we've"      "they've"    "i'd"        "you'd"
 [71] "he'd"       "she'd"      "we'd"       "they'd"     "i'll"
 [76] "you'll"     "he'll"      "she'll"     "we'll"      "they'll"
 [81] "isn't"      "aren't"     "wasn't"     "weren't"    "hasn't"
 [86] "haven't"    "hadn't"     "doesn't"    "don't"      "didn't"
 [91] "won't"      "wouldn't"   "shan't"     "shouldn't"  "can't"
 [96] "cannot"     "couldn't"   "mustn't"    "let's"      "that's"
```

API

APIs

- **API** - **A**pplication **P**rogramming **I**nterface.
- Programmatic way to interact with a software application/service.
- Widely used in computing (even on a single machine).
- Here, focus on web APIs, that provide interface to web services.
- A set of structured HTTP/S requests returns some responses.
  - E.g. in XML or JSON format.

APIs vs Web Scraping

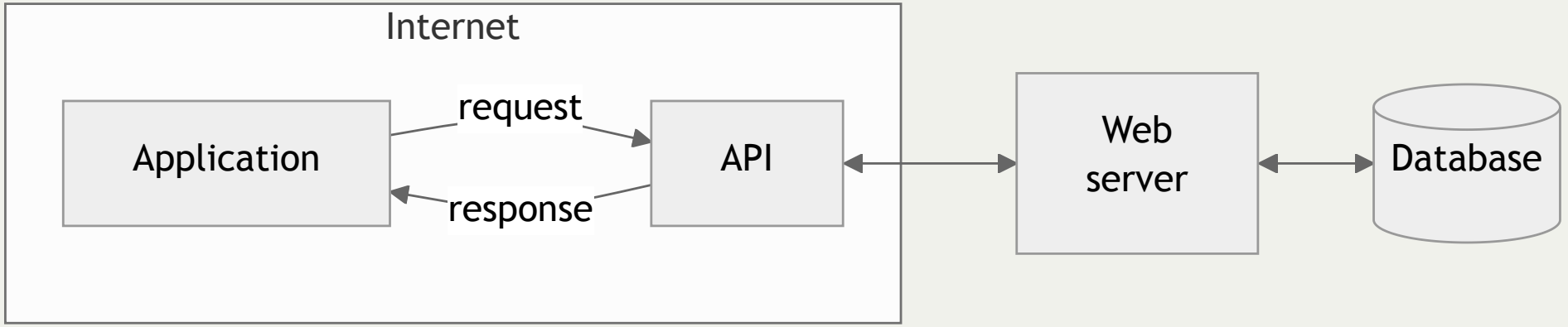
Advantages:

- Cleaner data collection: no malformed HTML, consistency, fewer legal issues, etc.
- Standardised data access processes.
- Scalability.
- Potentially, pre-existing robust packages for handling common tasks.

Disadvantages:

- Limited availability.
- Dependency on API providers.
- Access limits
- Rate limits.
- Price

Principles of APIs



Working with Web APIs

- Types of APIs:
  - **RESTful APIs** - queries for static information at a given moment,
  - **Streaming APIs** - tracking real-time changes (e.g. posts, economic indicators, etc.)
- API documentation varies by provider.
- But usually is rather technical in nature (written for developers).
- Some key terms:
  - **Endpoint** - URL (web location) that receives requests and sends responses.
  - **Parameters** - custom information that can be passed to the API.
  - **Response** - the data returned by the API.

Authentication

- Many APIs require a **key** or **tokens**.
- Most APIs are rate-limited
  - E.g. restrictions by user/key/IP address/time period.
- Make sure that you understand the terms of service/use.
- Even providers of public free APIs can impose some restrictions.

Example: Guardian API

```r
library("httr")
```

```r
# It is a good idea to not hard-code the API key in the script
# and, instead, load it dynamically from a file
api_key <- readLines("../temp/guardian_api_key.txt")
```

```r
# Endpoint
base_url <- "https://content.guardianapis.com/search"
```

```r
# Parameters
params <- list(
  "api-key" = api_key,
  "q" = "ireland",
  "page-size" = 1
)
```

```r
# Make the request and receive the response
response <- httr::GET(url = base_url, query = params)
```

```r
# Check the status of the response (200 means successful)
# Status codes 4xx are client errors; 5xx are server errors
response$status_code
```

```
[1] 200
```

```r
response
```

```
Response [https://content.guardianapis.com/search?api-key=2cae3602-5bc7-4c38-83e2-634c28798ba9&q=ireland&page-size=1]
  Date: 2025-03-19 12:39
  Status: 200
  Content-Type: application/json
  Size: 635 B
```

JSON

- **JSON** (**J**ava**S**cript **O**bject **N**otation) is a lightweight data-interchange format
- It is commonly used in web APIs (as well as elsewhere, e.g. Jupyter Notebooks).
- At its core, JSON objects are key-value pairs (often deeply nested).
- Keys have to be strings with double quotes.
- Values can be one of the following types:
  - String (e.g., “example”)
  - Number (e.g., 42, 3.141)
  - Array (e.g., [“a”, “b”, “c”])
  - Boolean (e.g., true, false)
  - null

Extra

JSON Syntax

JSON: Example

```r
library("jsonlite")
```

```r
json <- httr::content(response, as = "text", encoding = "UTF-8")
```

```r
json |>
  jsonlite::prettify()
```


```
{
    "response": {
        "status": "ok",
        "userTier": "developer",
        "total": 112805,
        "startIndex": 1,
        "pageSize": 1,
        "currentPage": 1,
        "pages": 112805,
        "orderBy": "relevance",
        "results": [
            {
                "id": "world/2024/dec/02/ireland-election-2024-latest-results",
                "type": "article",
                "sectionId": "world",
                "sectionName": "World news",
                "webPublicationDate": "2024-12-03T07:45:44Z",
                "webTitle": "Ireland election 2024: full results",
                "webUrl": "https://www.theguardian.com/world/2024/dec/02/ireland-election-2024-latest-results",
                "apiUrl": "https://content.guardianapis.com/world/2024/dec/02/ireland-election-2024-latest-results",
                "isHosted": false,
                "pillarId": "pillar/news",
                "pillarName": "News"
            }
        ]
    }
}
```

JSON Representation

- As JSON is just a text format, its representation in code will vary by language.
  - E.g. in R JSON -> list, in Python -> dictionary

```r
json_parsed <- jsonlite::fromJSON(json)
```

```r
str(json_parsed)
```

```
List of 1
 $ response:List of 9
  ..$ status     : chr "ok"
  ..$ userTier   : chr "developer"
  ..$ total      : int 112805
  ..$ startIndex : int 1
  ..$ pageSize   : int 1
  ..$ currentPage: int 1
  ..$ pages      : int 112805
  ..$ orderBy    : chr "relevance"
  ..$ results    :'data.frame': 1 obs. of  11 variables:
  .. ..$ id                  : chr "world/2024/dec/02/ireland-election-2024-latest-results"
  .. ..$ type                : chr "article"
  .. ..$ sectionId           : chr "world"
  .. ..$ sectionName         : chr "World news"
  .. ..$ webPublicationDate: chr "2024-12-03T07:45:44Z"
  .. ..$ webTitle            : chr "Ireland election 2024: full results"
  .. ..$ webUrl              : chr "https://www.theguardian.com/world/2024/dec/02/ireland-election-2024-latest-
results"
  .. ..$ apiUrl              : chr "https://content.guardianapis.com/world/2024/dec/02/ireland-election-2024-
```

JSON Representation

```
1 dim(json_parsed$response$results)
```

```
[1]  1 11
```

```
1 head(json_parsed$response$results)
```

```
                                                  id    type sectionId
1 world/2024/dec/02/ireland-election-2024-latest-results article     world
  sectionName   webPublicationDate                          webTitle
1  World news 2024-12-03T07:45:44Z Ireland election 2024: full results
                                                                    webUrl
1 https://www.theguardian.com/world/2024/dec/02/ireland-election-2024-latest-results
                                                                          apiUrl
1 https://content.guardianapis.com/world/2024/dec/02/ireland-election-2024-latest-results
  isHosted    pillarId pillarName
1    FALSE pillar/news       News
```

Next

- Tutorial: Text Preprocessing and APIs
- Next week: Classifying texts
- Assignment 1: Due 15:59 on Wednesday, 26th March (submission on Blackboard)