Data Science

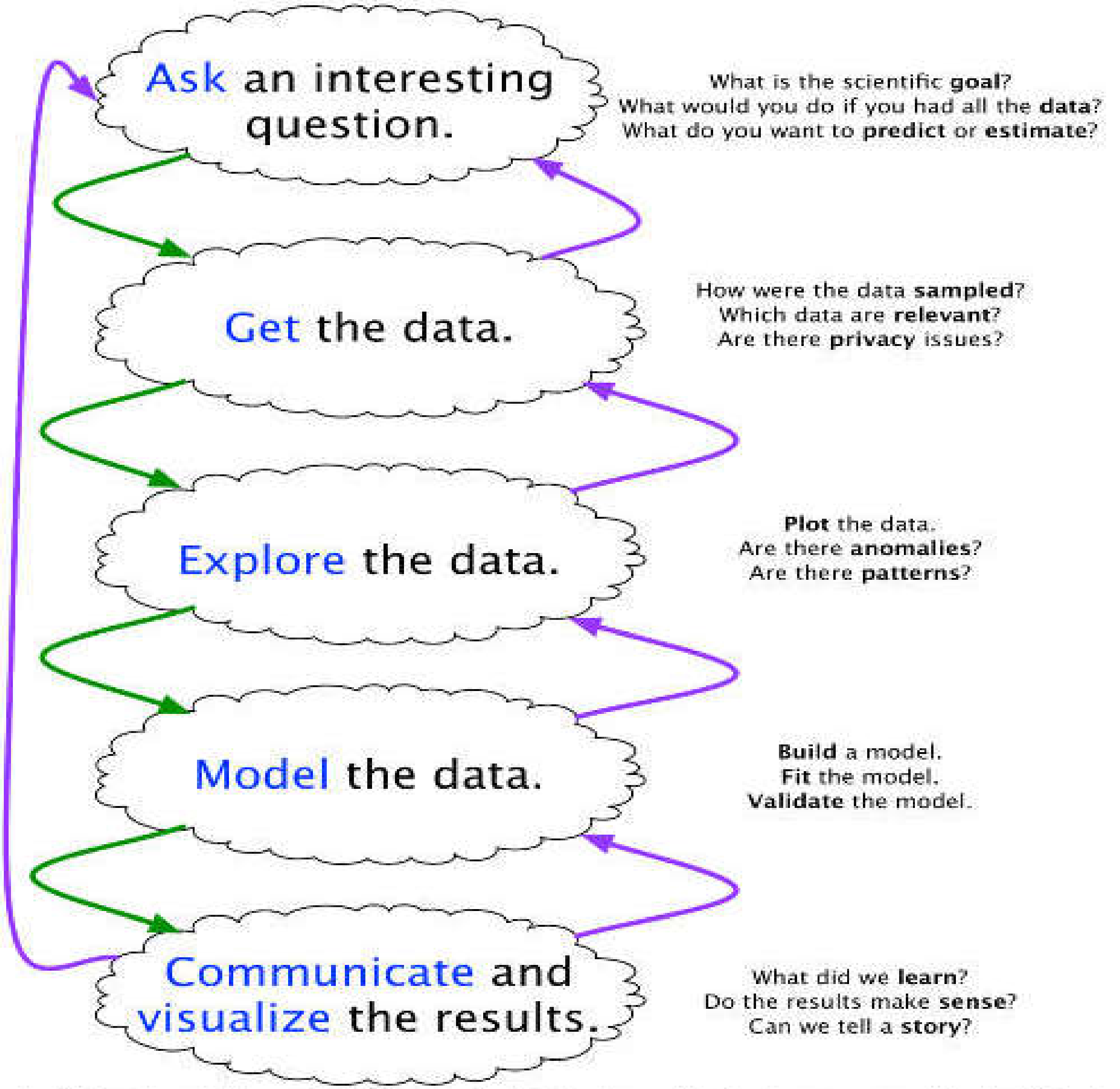
A Discussion on Data

The Data Science Process

- Ask questions
- Data Collection
- Data Exploration
- Data Modeling
- Data Analysis
- Visualization and Presentation of Results

Today we will begin introducing the data collection and data exploration steps.

The Data Science Process



Ask an interesting question.

What is the scientific **goal**?
What would you do if you had all the **data**?
What do you want to **predict** or **estimate**?

Get the data.

How were the data **sampled**?
Which data are **relevant**?
Are there **privacy** issues?

Explore the data.

Plot the data.
Are there **anomalies**?
Are there **patterns**?

Model the data.

Build a model.
Fit the model.
Validate the model.

Communicate and **visualize** the results.

What did we **learn**?
Do the results make **sense**?
Can we tell a **story**?

Joe Blitzstein and Hanspeter Pfister, created for the Harvard data science course http://cs109.org/.

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- Exploratory Data Analysis
  - Examining data to observe patterns, find issues using Statistics and Visualization

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- Everything is data!

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- External Sources Requiring Collection Efforts
  - Available from external sources but acquisition requires special processing
  - Printed data; website data

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- Web Scraping
  - Using software, scripts or by hand extracting data from what is displayed on a page or what is contained in the HTML file.

Web Scraping

- Older govt. or smaller news sites might not have APIs for accessing data, or publish RSS feeds or have databases for download.
- One doesn’t want to pay for API or database access!
- Should we do it?
    - For exploration or publishing the analysis or product
    - See terms of services
    - Check privacy concerns for websites and their clients

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- Categorical variable
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    - What kind of pet do you have?
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    - User Rating {1,2, 3, 4, 5}, {Agree, Slightly Agree, Neither, Slightly Disagree, Disagee}

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Types of Data

- What kind of values are in the data – Compound, composed of a bunch of atomic types?
- Date and time
    - Compound value with a specific structure
- Lists
    - A sequence of values
- Dictionaries
    - A collection of key-value pair

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- Semi-structured data
  - Not all records are represented by the same set of keys or some data records are not represented using the key-value pair structure.

CSV, Comma Separated Values

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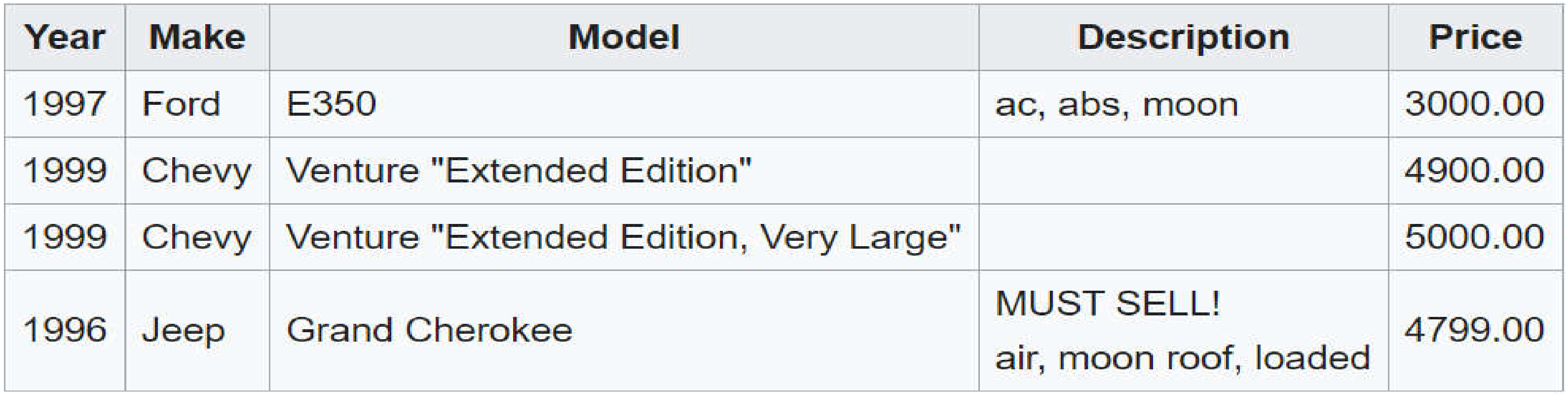

Year	Make	Model	Description	Price
1997	Ford	E350	ac, abs, moon	3000.00
1999	Chevy	Venture "Extended Edition"		4900.00
1999	Chevy	Venture "Extended Edition, Very Large"		5000.00
1996	Jeep	Grand Cherokee	MUST SELL! air, moon roof, loaded	4799.00

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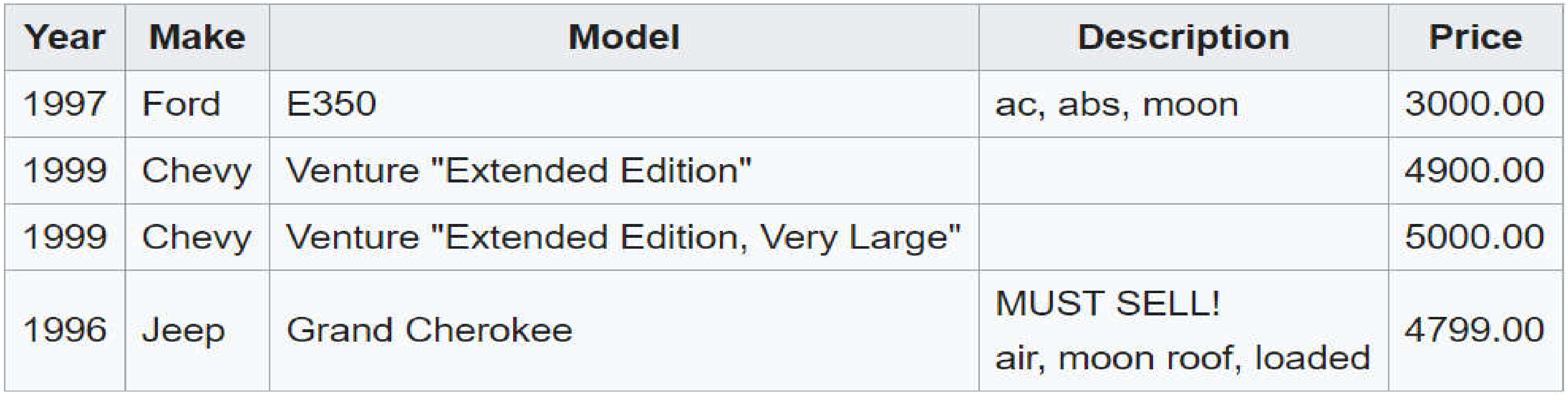

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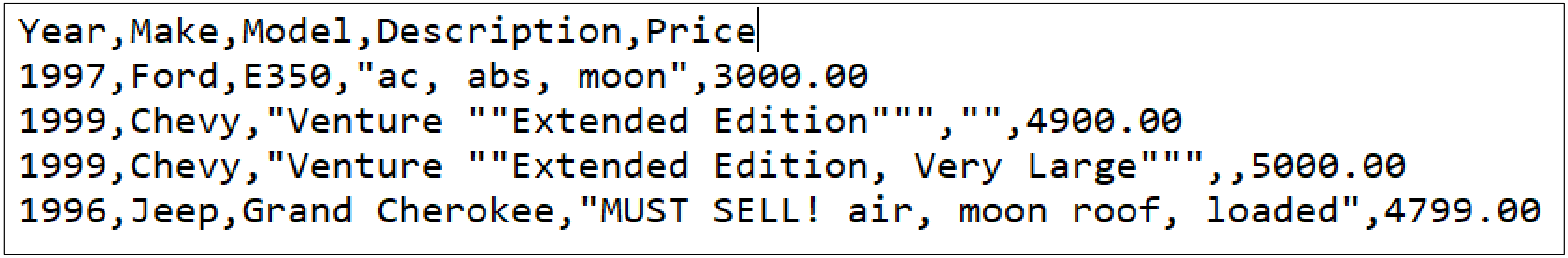

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Hierarchies, e.g. Newick Tree

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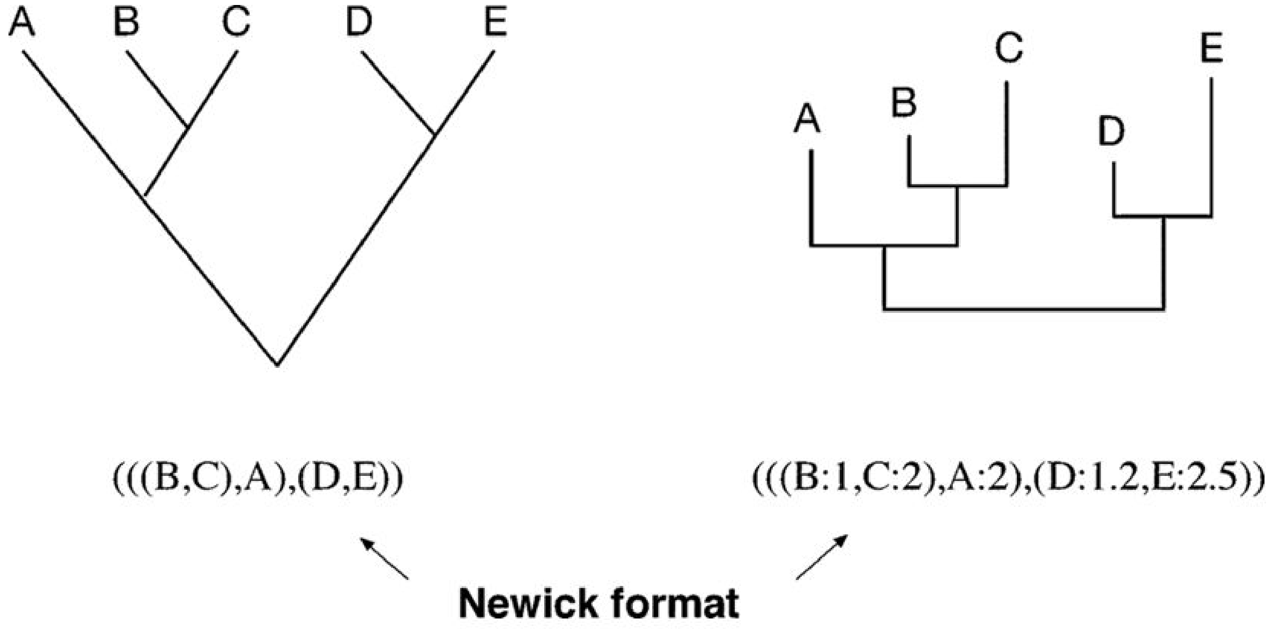

(((B,C),A),(D,E))

(((B:1,C:2),A:2),(D:1.2,E:2.5))

Newick format

JSON, JavaScript Object Notation

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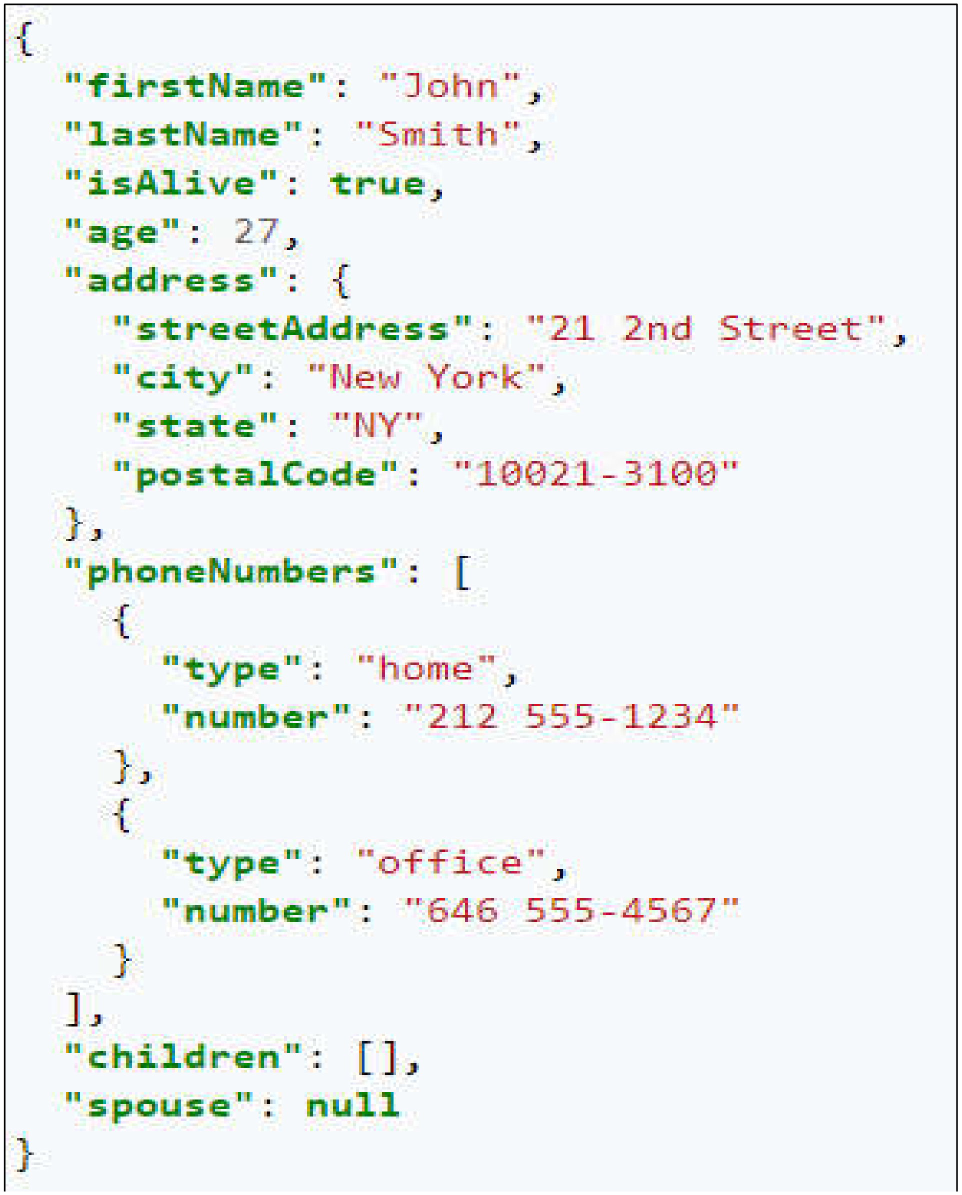

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{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 27,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

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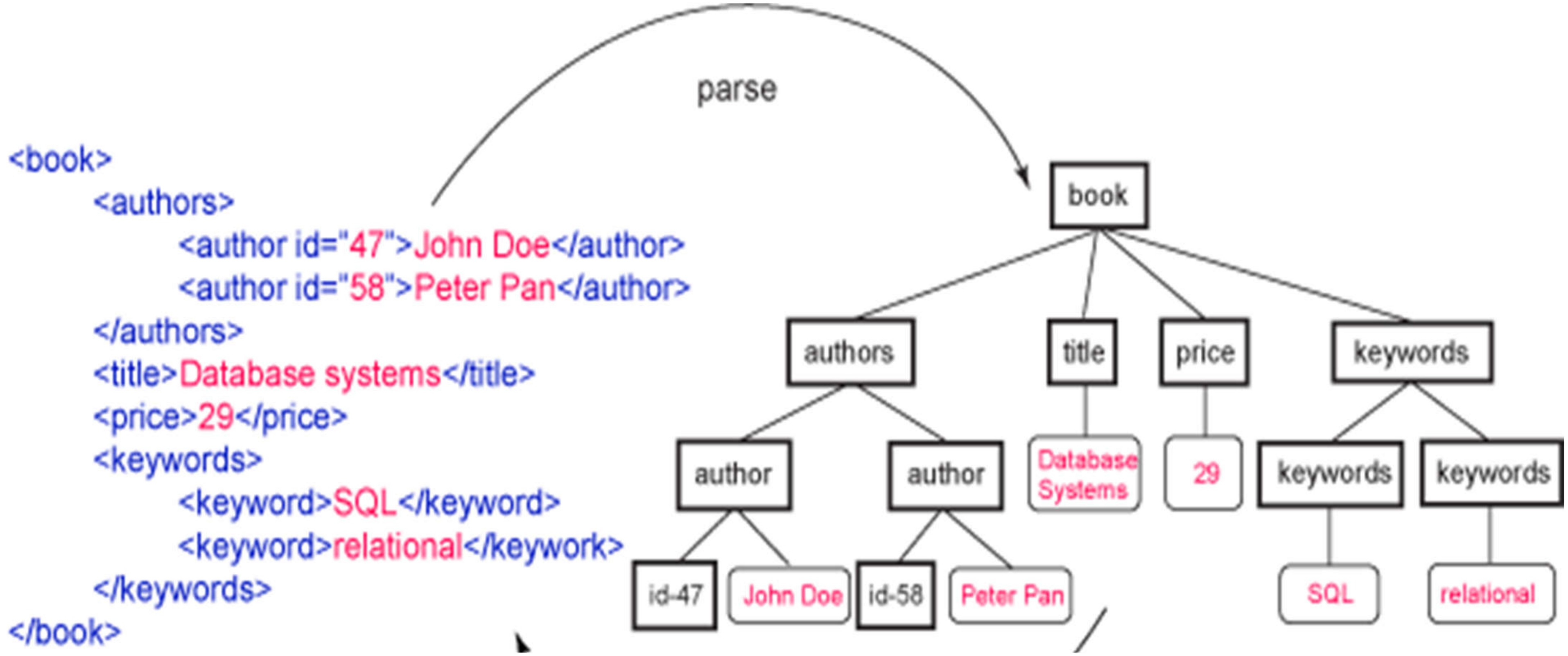

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                <author id="47">John Doe</author>
                <author id="58">Peter Pan</author>
        </authors>
        <title>Database systems</title>
        <price>29</price>
        <keywords>
                <keyword>SQL</keyword>
                <keyword>relational</keywork>
        </keywords>
</book>
```
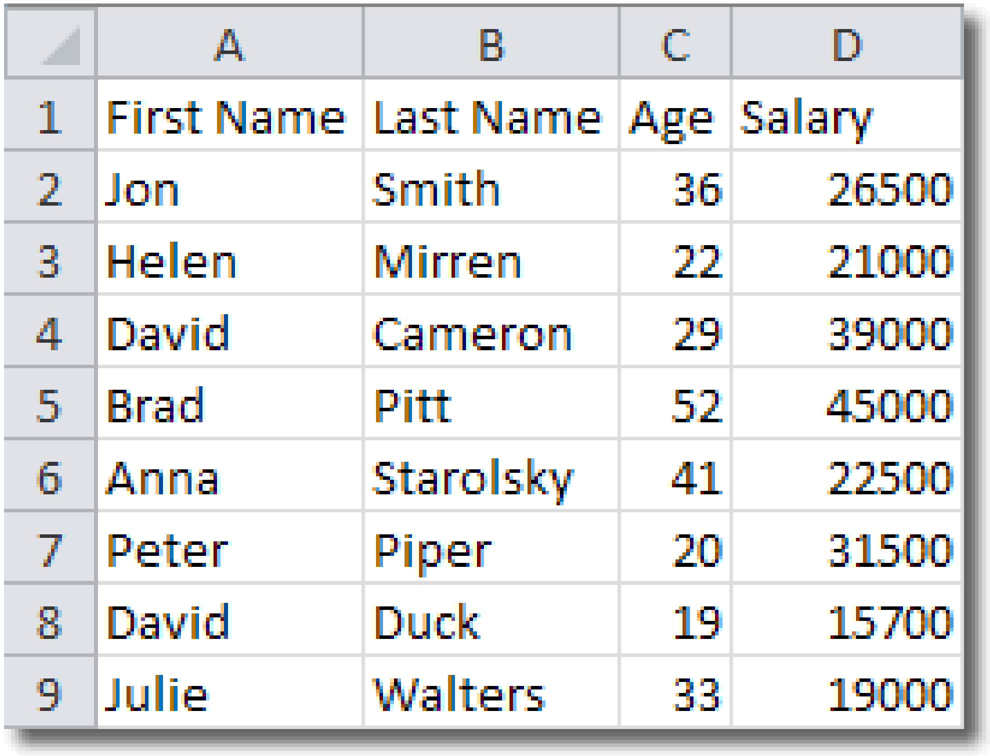

Tabular Data



	A	B	C	D
1	First Name	Last Name	Age	Salary
2	Jon	Smith	36	26500
3	Helen	Mirren	22	21000
4	David	Cameron	29	39000
5	Brad	Pitt	52	45000
6	Anna	Starolsky	41	22500
7	Peter	Piper	20	31500
8	David	Duck	19	15700
9	Julie	Walters	33	19000

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- Each type of measurement is called a variable or an attribute (feature/Predictor) of the data.
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- We expect each table to contain a set of records or observations of the same kind of object or event.

Common issues with the data

- Missing values
  - How to fill in?

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- Wrong values
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  - Convert

Common issues with the data

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- Wrong values
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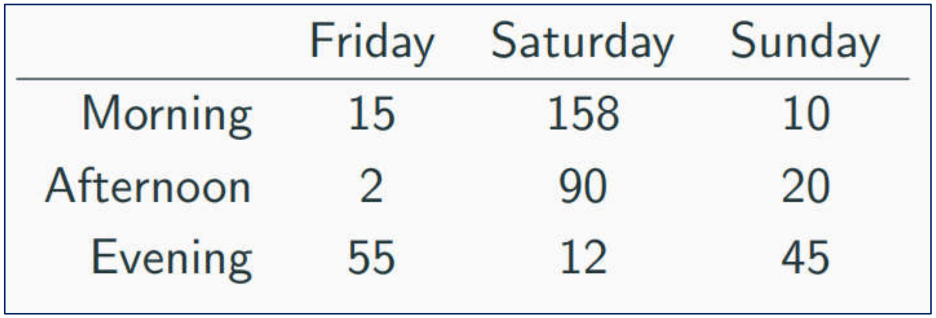
- Messy format
    - Convert
- Not usable
    - The data cannot answer the question asked

Handling Messy Data

- The following is a table accounting for the number of product deliveries over a weekend

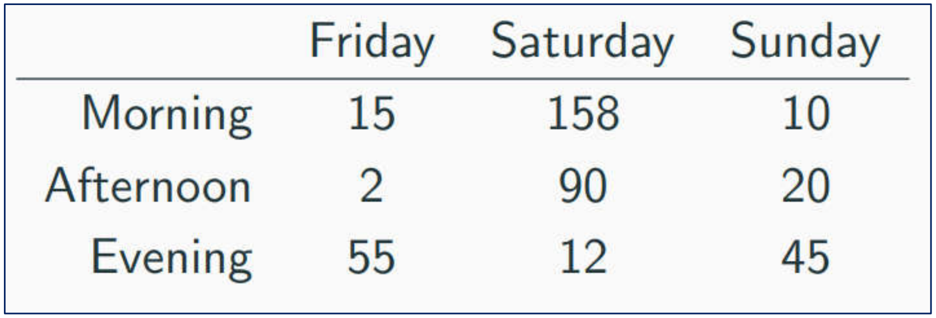


	Friday	Saturday	Sunday
Morning	15	158	10
Afternoon	2	90	20
Evening	55	12	45

- What are the variables?
- What object or event are we measuring?
- What's the issue? How to fix this?

Handling Messy Data

- Measuring individual deliveries
- The variables are Time, Day, Number of Products



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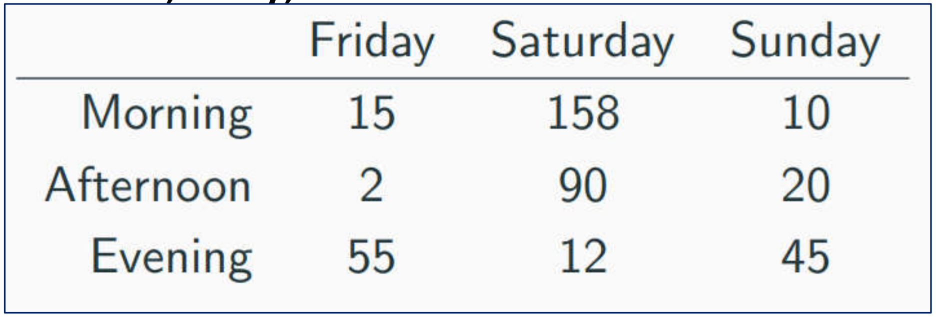

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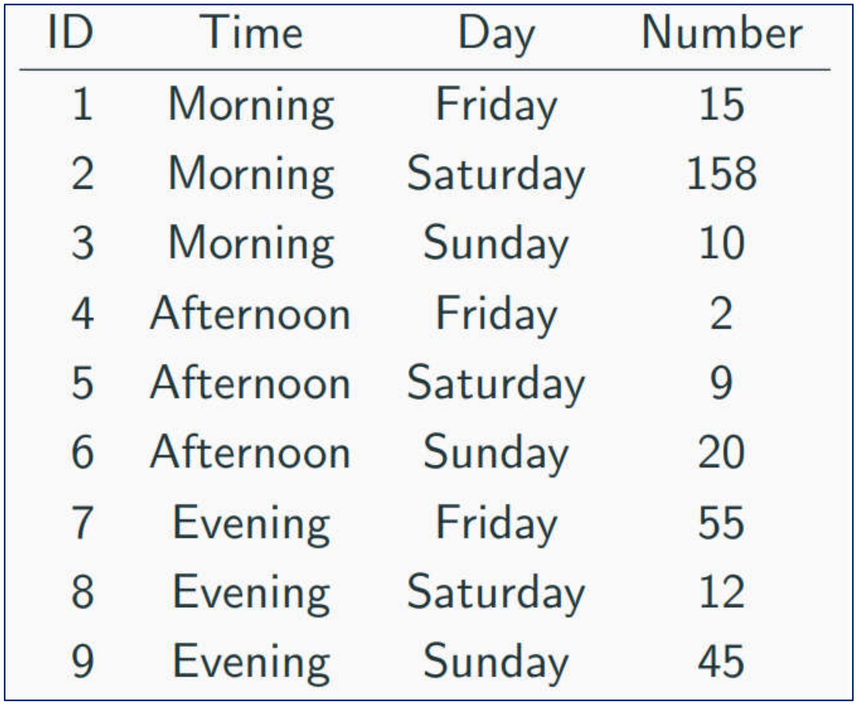
- Problem
  - Each column header represents a single value rather than a variable
  - Row headers are hiding the day variable
  - The values of the variable “Number of products” is not recorded in a single column.

Handling Messy Data

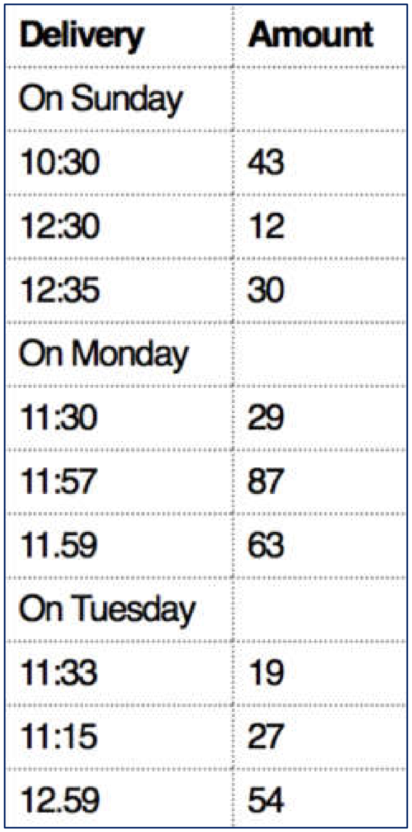
- We need to reorganize the information to make explicit the event were observing and the variables associated to the event.



ID	Time	Day	Number
1	Morning	Friday	15
2	Morning	Saturday	158
3	Morning	Sunday	10
4	Afternoon	Friday	2
5	Afternoon	Saturday	9
6	Afternoon	Sunday	20
7	Evening	Friday	55
8	Evening	Saturday	12
9	Evening	Sunday	45

More Messiness

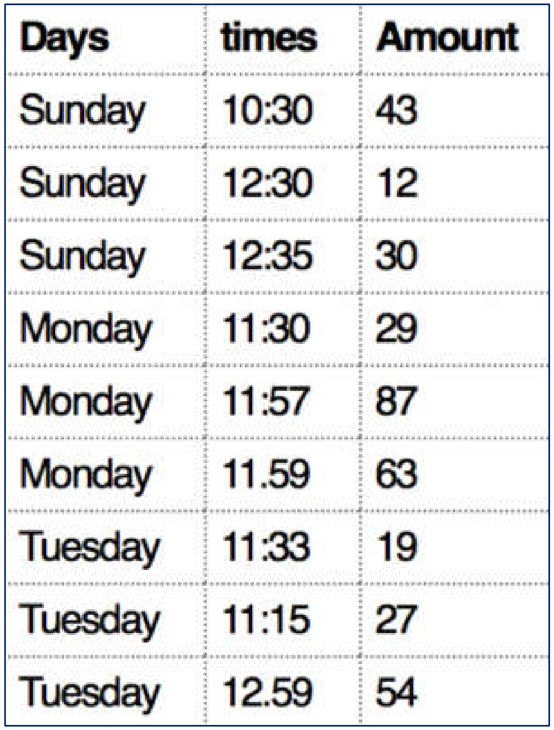
- What object or event we are measuring?
- What are the variables in this dataset?
- How do we fix it?



Delivery	Amount
On Sunday	
10:30	43
12:30	12
12:35	30
On Monday	
11:30	29
11:57	87
11.59	63
On Tuesday	
11:33	19
11:15	27
12.59	54

More Messiness

- Were measuring Individual Deliveries
- The variables are
  - Time, Day, Number of Products



Days	times	Amount
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Monday	11:30	29
Monday	11:57	87
Monday	11.59	63
Tuesday	11:33	19
Tuesday	11:15	27
Tuesday	12.59	54

Common Causes of Messiness

- Column headers are values, not variable names
- Variables are stored in both rows and columns
- Multiple variables are stored in one column
- Multiple types of experimental units are stored in same table

Tabularized Data

- In general, we want each file to correspond to a dataset
- We want to tabularize the data
- Each column to represent a single variable
- Each row to represent a single observation

Example Datasets

- UCI Machine Learning Data Repository
  - https://archive.ics.uci.edu/ml/datasets

data collection for dissertation?
COMPLETE.
quickmeme.com