

Data types & Vectors & Pivoting

Research Beyond the Lab: Open Science and Research Methods
for a Global Engineer

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2025-03-27

Learning Objectives (for this week)

1. Learners can identify different ways of accessing a vector from a dataframe
2. Learners can list the four main atomic vector types in R.
3. Learners can apply functions from the `tidyR` R Package to transform their data from a wide to a long format and vice versa.

Part 1: Cross-references

Cross references

- Help readers to navigate your document with numbered references and hyperlinks to entities like figures and tables.
- Cross referencing steps:
 - Add a caption to your figure or table.
 - Give an ID to your figure or table, starting with `fig-` or `tbl-`.
 - Refer to it with `@fig-...` or `@tbl-....`

Table cross references

The presence of the caption ([A few penguins](#)) and label ([#tbl-penguins](#)) make this table reference-able:

See [@tbl-penguins](#) for data on a few penguins.

becomes:

See [Table 1](#) for data on a few penguins.

```
1 ````{r}
2 #| label: tbl-penguins
3 #| tbl-cap: A few penguins
4
5 head(penguins) |>
6   gt()
7 ````
```

Table 1: A few penguins

species	island	bill_length_mm	bill_depth_mm	flipper_length_mm	body_mass_g	sex	year
Adelie	Torgersen	39.1	18.7	181	3750	male	2007
Adelie	Torgersen	39.5	17.4	186	3800	female	2007
Adelie	Torgersen	40.3	18.0	195	3250	female	2007
Adelie	Torgersen	NA	NA	NA	NA	NA	2007
Adelie	Torgersen	36.7	19.3	193	3450	female	2007

Figure cross references

The presence of the caption ([A few penguins](#)) and label (#fig-penguins) make this figure reference-able:

See [@fig-penguins](#) for data on a few penguins.

becomes:

See [Figure 1](#) for data on a few penguins.

```
1 ````{r}
2 #| label: fig-penguins
3 #| fig-cap: A few penguins
4 #| fig-width: 6
5 #| fig-asp: 0.618
6
7 ggplot(penguins, aes(x = species, fill = species)) +
8   geom_bar(show.legend = FALSE)
9 ````
```

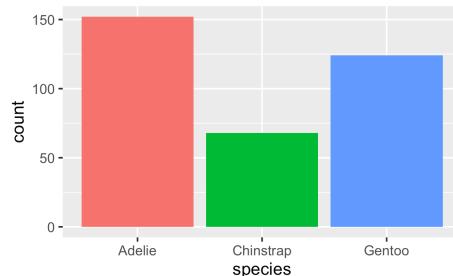


Figure 1: A few penguins

Your turn: md-06-exercises - cross-references

1. Open [posit.cloud](#) in your browser (use your bookmark).
2. Open the [rbtl-fs25 workspace](#) for the course.
3. In the File Manager in the bottom right window, locate the [md-06a-cross-references.qmd](#) file and click on it to open it in the top left window.
4. Follow instructions in the file

Part 2: Data types and vectors

Why care about data types?

Example: survey data

A survey about recycling behaviour in the city of Zurich:

- `job`: What is your occupation?
- `price_glass`: What monthly subscription would you be willing to pay for a metal/glass bin outside your home?

<code>id</code>	<code>job</code>	<code>price_glass</code>
1	Student	0
2	Retired	0
3	Other	0
4	Employed	10
5	Employed	See comment
6	Student	5-10
7	Student	0
8	Retired	0
9	Student	10

id	job	price_glass
10	Employed	0
11	Employed	20 (2chf per person with 10 people in the WG)
12	Student	10
13	Student	10
14	Employed	0
15	Student	10
16	Student	0
17	Employed	5-10
18	Other	0
19	Student	0
20	Employed	10
21	Employed	0
22	Employed	5

Oh why won't you work?!

```
1 survey_data_small |>
2   summarise(mean_price_glass = mean(price_glass))

# A tibble: 1 × 1
  mean_price_glass
  <dbl>
1       NA
```

Oh why won't you still work??!!

```
1 survey_data_small |>
2   summarise(mean_price_glass = mean(price_glass, na.rm = TRUE))

# A tibble: 1 × 1
  mean_price_glass
  <dbl>
1       NA
```

Take a breath and look at your data

<code>id</code>	<code>job</code>	<code>price_glass</code>
1	Student	0
2	Retired	0
3	Other	0
4	Employed	10
5	Employed	See comment
6	Student	5-10
7	Student	0
8	Retired	0
9	Student	10
10	Employed	0
11	Employed	20 (2chf per person with 10 people in the WG)
12	Student	10
13	Student	10
14	Employed	0  rbtl-fs25.github.io/website/

id	job	price_glass
15	Student	10
16	Student	0
17	Employed	5-10
18	Other	0
19	Student	0
20	Employed	10
21	Employed	0
22	Employed	5

Take a breath and look at your data

```
# A tibble: 22 × 3
  id   job      price_glass
  <int> <chr>    <chr>
1     1 Student   0
2     2 Retired   0
3     3 Other     0
4     4 Employed  10
5     5 Employed  See comment
6     6 Student   5-10
7     7 Student   0
8     8 Retired   0
9     9 Student   10
10    10 Employed 0
# i 12 more rows
```

Very common data tidying step!

```
1 survey_data_small |>  
2   mutate(price_glass_new = case_when(  
3     price_glass == "5-10" ~ "7.5",  
4     price_glass == "05-Oct" ~ "7.5",  
5     str_detect(price_glass, pattern = "2chf") == TRUE ~ "2",  
6     str_detect(price_glass, pattern = "See comment") == TRUE ~ NA_character_,  
7     TRUE ~ price_glass  
8   ))
```

Very common data tidying step!

<code>id</code>	<code>job</code>	<code>price_glass_new</code>	<code>price_glass</code>
1	Student	0	0
2	Retired	0	0
3	Other	0	0
4	Employed	10	10
5	Employed	NA	See comment
6	Student	7.5	5-10
7	Student	0	0
8	Retired	0	0
9	Student	10	10
10	Employed	0	0
11	Employed	2	20 (2chf per person with 10 people in the WG)
12	Student	10	10
13	Student	10	10 ✉ rbtl-fs25.github.io/website/

id	job	price_glass_new	price_glass
14	Employed	0	0
15	Student	10	10
16	Student	0	0
17	Employed	7.5	5-10
18	Other	0	0
19	Student	0	0
20	Employed	10	10
21	Employed	0	0
22	Employed	5	5

Sumamrise? Argh!!!!

```
1 survey_data_small |>
2   mutate(price_glass_new = case_when(
3     price_glass == "5-10" ~ "7.5",
4     price_glass == "05-Oct" ~ "7.5",
5     str_detect(price_glass, pattern = "2chf") == TRUE ~ "2",
6     str_detect(price_glass, pattern = "See comment") == TRUE ~ NA_character_,
7     TRUE ~ price_glass
8   )) |>
9   summarise(mean_price_glass = mean(price_glass_new, na.rm = TRUE))
```

```
# A tibble: 1 × 1
  mean_price_glass
                <dbl>
1                  NA
```

Always respect your data types!

! Taking the mean of vector with type “character” is not possible.

```
# A tibble: 22 × 4
  id job      price_glass price_glass_new
  <int> <chr>    <chr>        <chr>
1 1 Student 0          0
2 2 Retired 0          0
3 3 Other   0          0
4 4 Employed 10        10
5 5 Employed See comment <NA>
6 6 Student 5-10      7.5
7 7 Student 0          0
8 8 Retired 0          0
9 9 Student 10        10
10 10 Employed 0          0
# ... with 12 more rows
```

Always respect your data types!

```
1 survey_data_small |>
2   mutate(price_glass_new = case_when(
3     price_glass == "5-10" ~ "7.5",
4     price_glass == "05-Oct" ~ "7.5",
5     str_detect(price_glass, pattern = "2chf") == TRUE ~ "2",
6     str_detect(price_glass, pattern = "See comment") == TRUE ~ NA_character_,
7     TRUE ~ price_glass
8   )) |>
9   mutate(price_glass_new = as.numeric(price_glass_new)) |>
10  summarise(mean_price_glass = mean(price_glass_new, na.rm = TRUE))

# A tibble: 1 × 1
mean_price_glass
<dbl>
1      3.90
```

My turn: Types of vectors & For loops

Sit back and enjoy!

Take a break

Please get up and move! Let your emails rest in peace.



Your turn: md-06-exercises - types

1. Open [posit.cloud](#) in your browser (use your bookmark).
2. Open the [rbtl-fs25 workspace](#) for the course.
3. In the File Manager in the bottom right window, locate the [md-06b-types-your-turn.qmd](#) file and click on it to open it in the top left window.
4. Follow instructions in the file

Take a break

Please get up and move! Let your emails rest in peace.



Part 3: `tidyr` - long and wide formats

TIDY DATA

is a standard way of mapping the meaning of a dataset to its structure.

—HADLEY WICKHAM

In tidy data:

- each variable forms a column
- each observation forms a row
- each cell is a single measurement

each column a variable

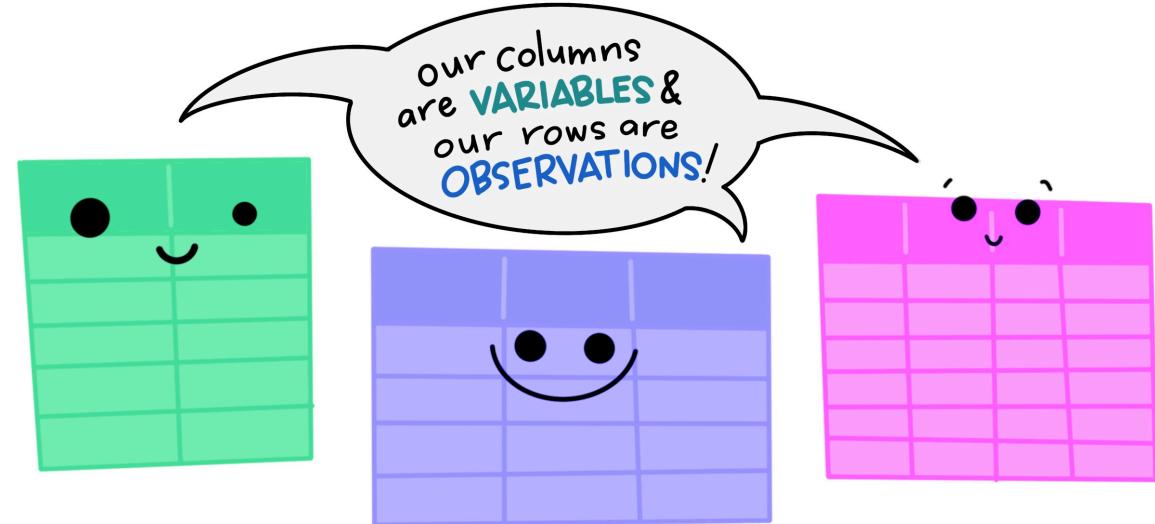
id	name	color
1	floof	gray
2	max	black
3	cat	orange
4	donut	gray
5	merlin	black
6	panda	calico

each row an observation

Wickham, H. (2014). Tidy Data. Journal of Statistical Software 59 (10). DOI: 10.18637/jss.v059.i10

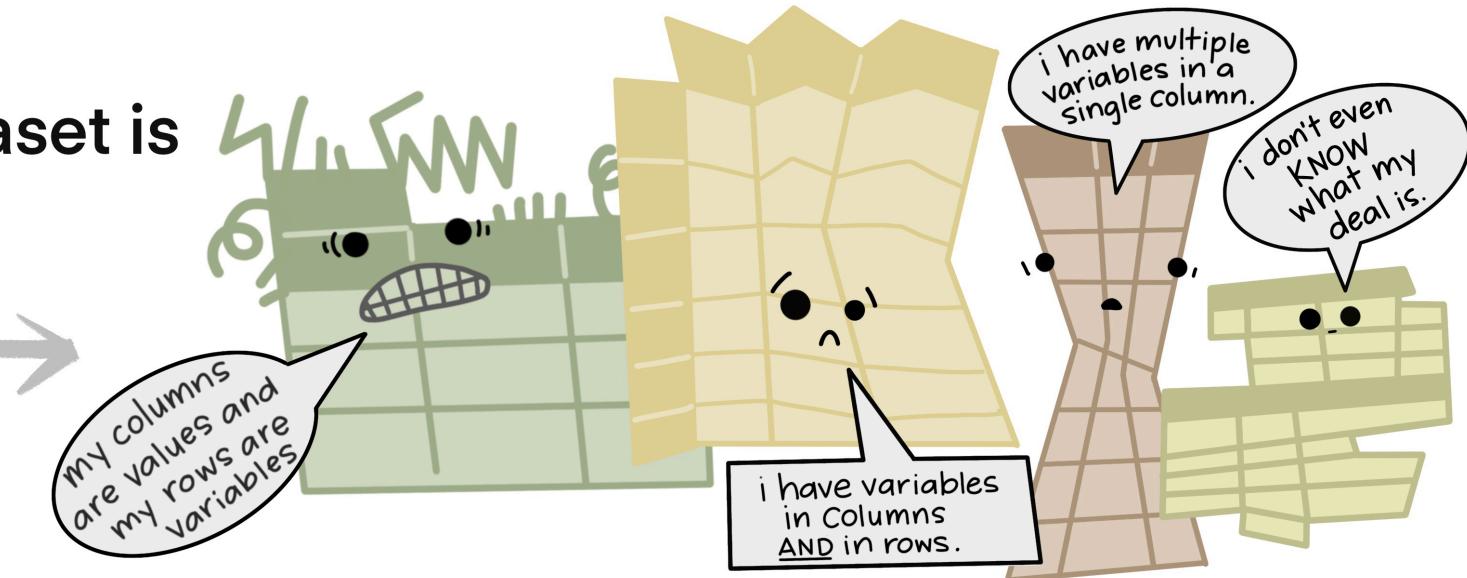
Illustrations from the [Openscapes](#) blog [Tidy Data for reproducibility, efficiency, and](#)
@rbtl-ts25.github.io/website/

The standard structure of
tidy data means that
“tidy datasets are all alike...”



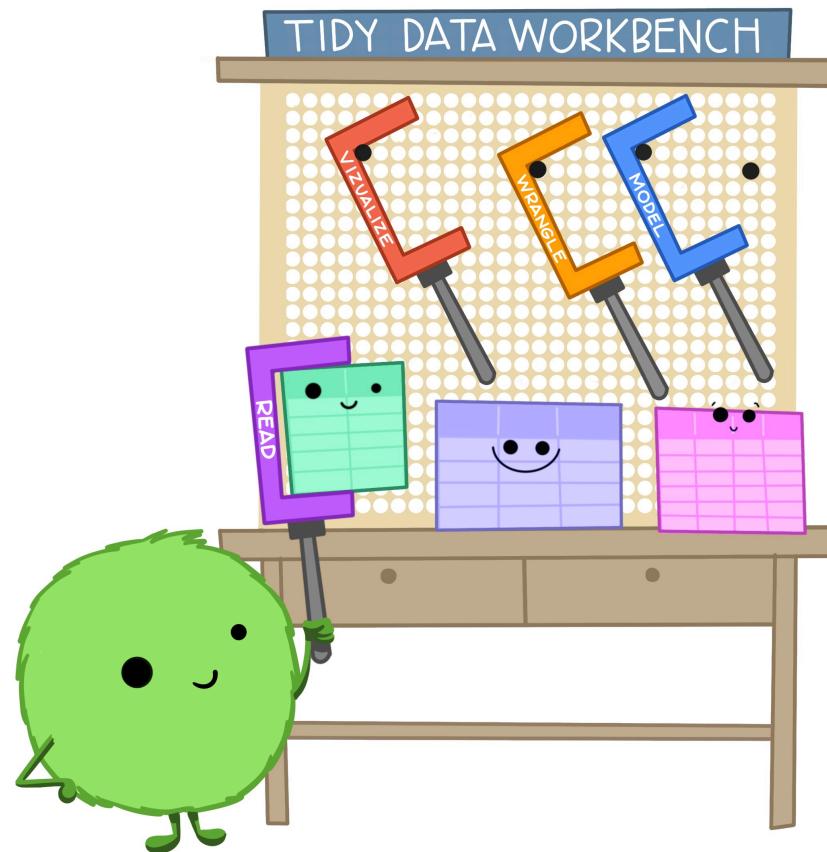
“...but every messy dataset is
messy in its own way.”

-HADLEY WICKHAM

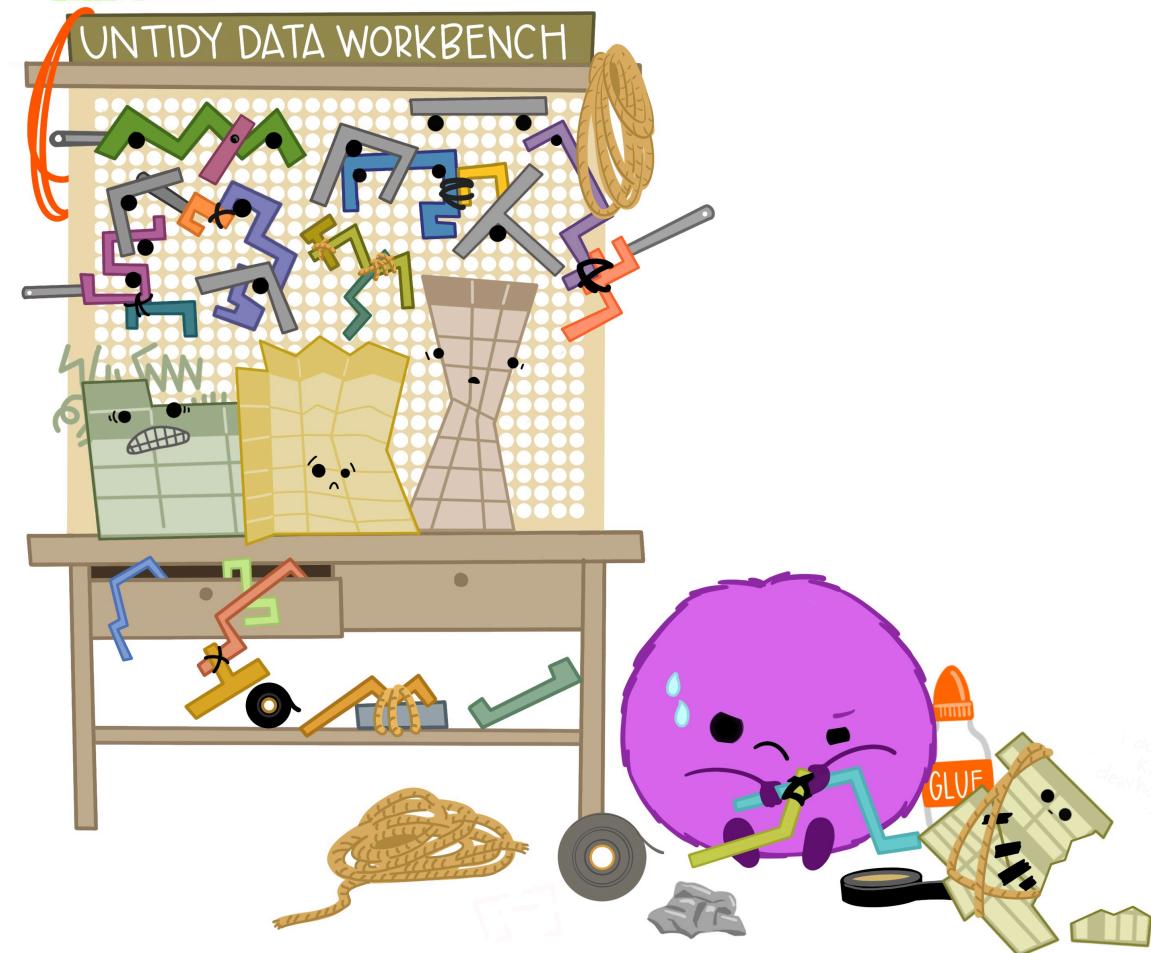


-

When working with tidy data,
we can use the **same tools** in
similar ways for different datasets...

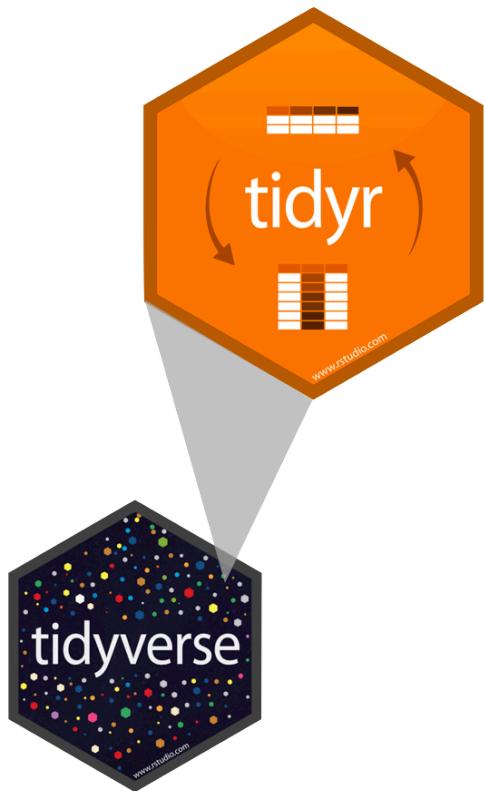


...but working with untidy data often means
reinventing the wheel with **one-time**
approaches that are **hard to iterate or reuse**.



Illustrations from the [Openscapes](#) blog [Tidy Data for reproducibility, efficiency, and](#)
[@rbtl-ts25.github.io/website/](https://rbtl-ts25.github.io/website/)

A grammar of data tidying



The goal of `tidyr` is to help you tidy your data via

- pivoting for going between wide and long data
- splitting and combining character columns
- nesting and unnesting columns
- clarifying how `NAs` should be treated

Pivoting data

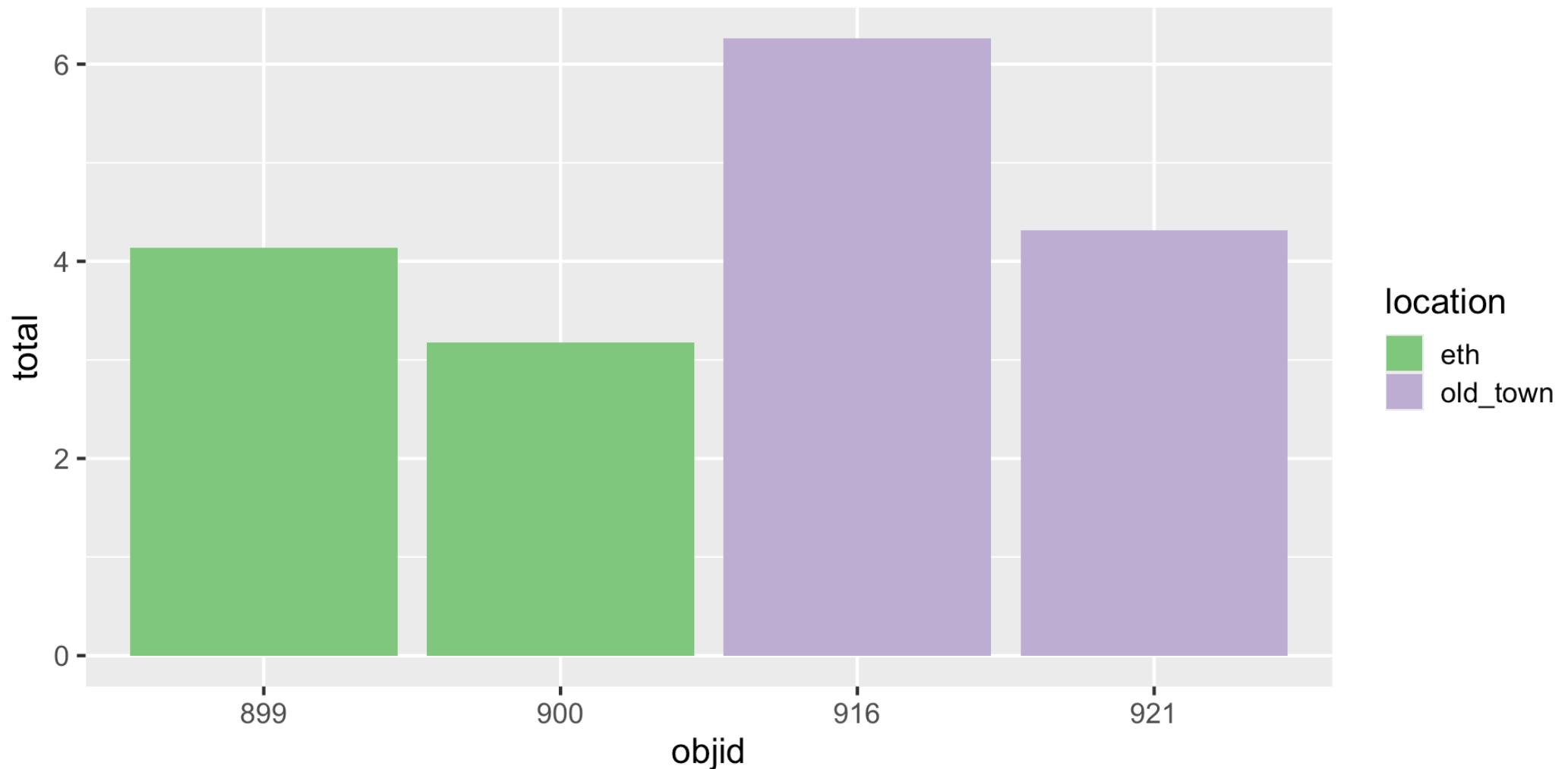
wide

id	x	y	z
1	a	c	e
2	b	d	f

Waste characterisation data

objid	location	pet	metal_alu	glass	paper	other	total
900	eth	0.06	0.06	0.58	0.21	1.14	2.05
899	eth	0.14	0.01	0.18	0.28	3.04	3.64
921	old_town	0.00	0.00	0.00	0.41	1.57	1.99
916	old_town	0.17	0.04	0.80	0.55	0.62	2.19
900	eth	0.10	0.04	0.00	0.40	0.58	1.12
899	eth	0.08	0.03	0.00	0.05	0.34	0.50
921	old_town	0.08	0.03	0.30	0.40	1.52	2.33
916	old_town	0.11	0.04	0.92	1.01	1.99	4.07

How would you plot this?

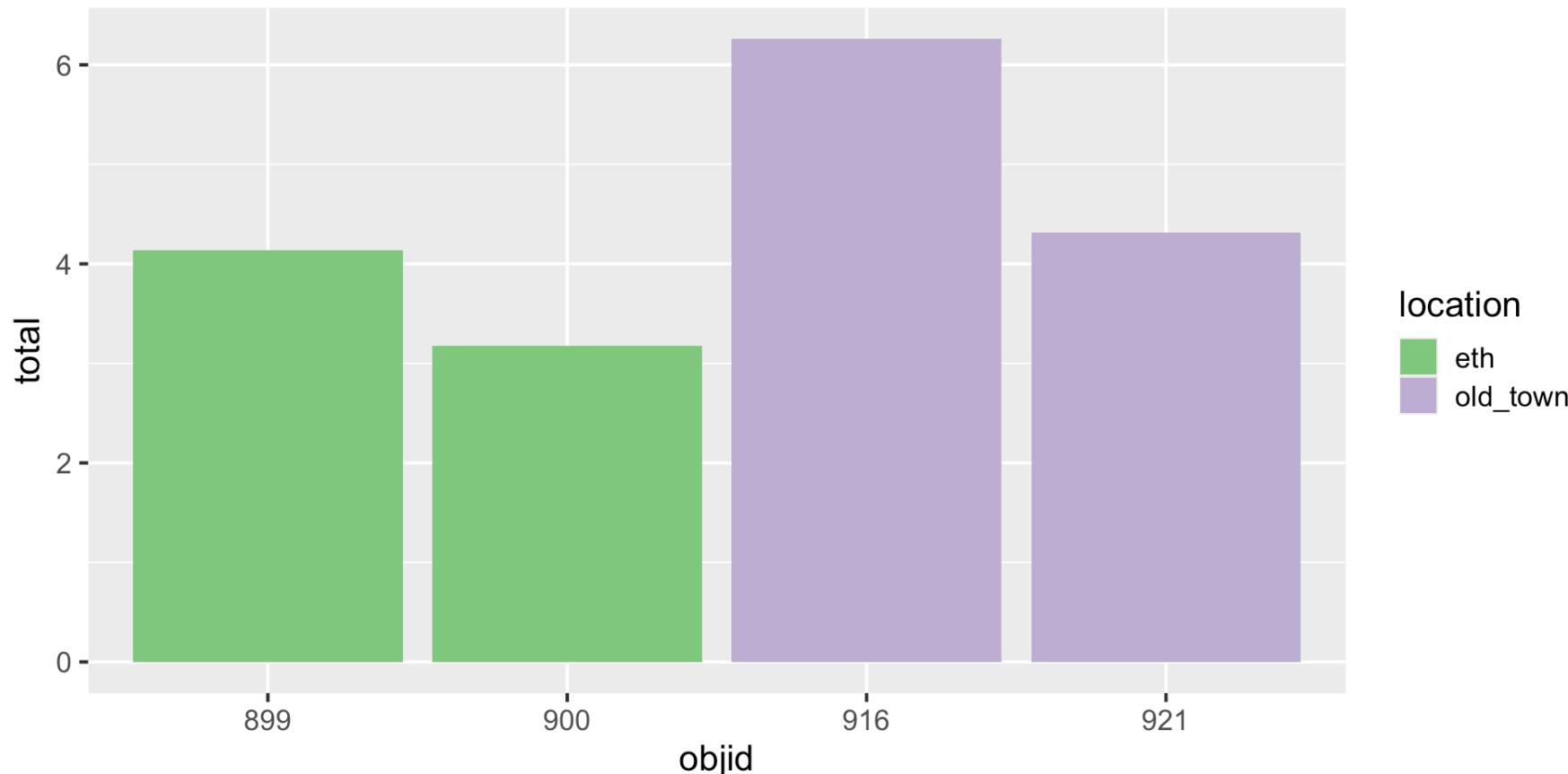


Three variables

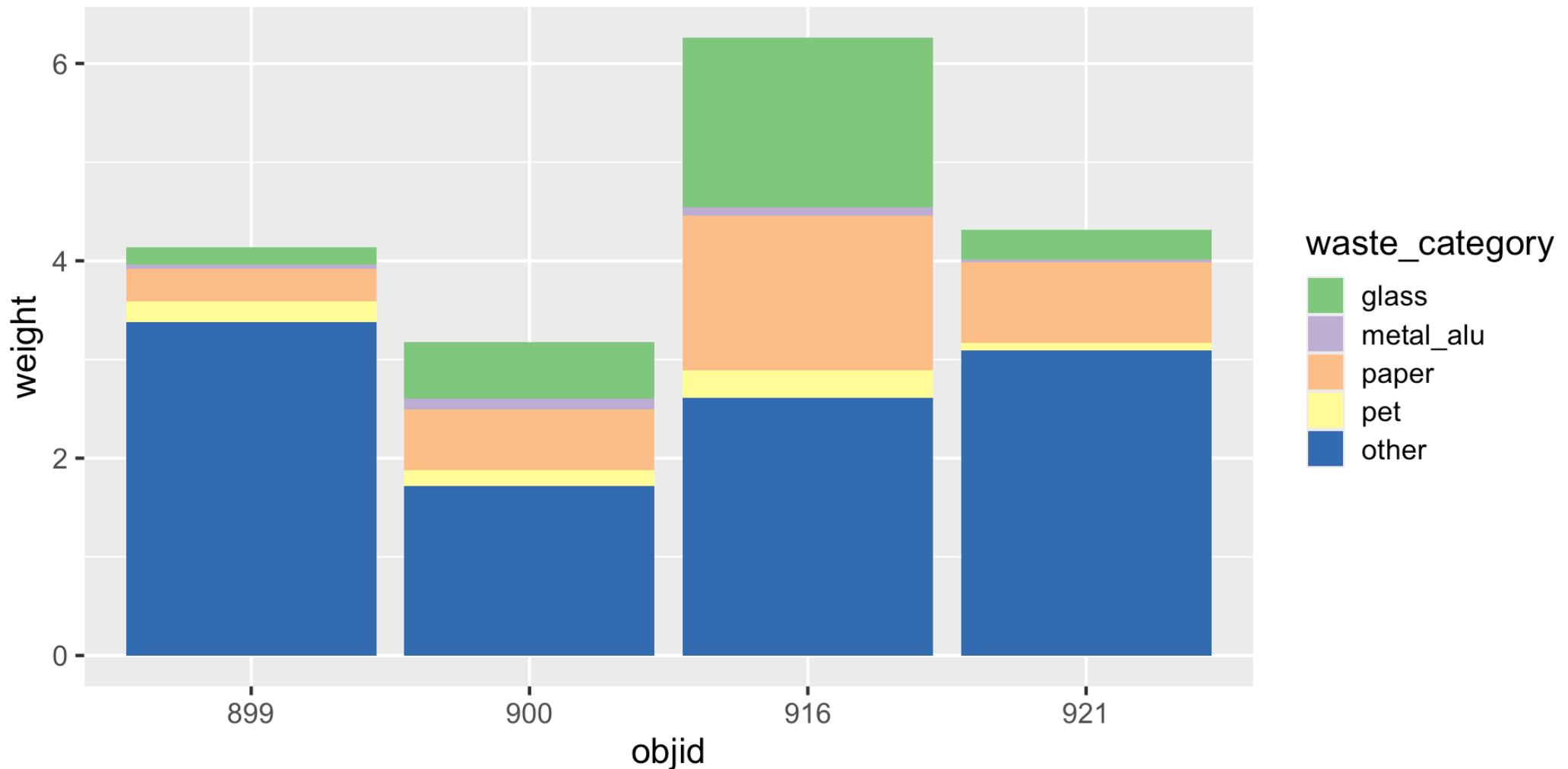
objid	location	total
900	eth	2.05
899	eth	3.64
921	old_town	1.99
916	old_town	2.19
900	eth	1.12
899	eth	0.50
921	old_town	2.33
916	old_town	4.07

Three variables -> three aesthetics

```
1 ggplot(data = waste_data_untidy,  
2         mapping = aes(x = objid,  
3                           y = total,  
4                           fill = location)) +  
5   geom_col() +  
6   scale_fill_brewer(type = "qual")
```



And how to plot this?



Reminder: Data (in wide format)

objid	location	pet	metal_alu	glass	paper	other
900	eth	0.06	0.06	0.58	0.21	1.14
899	eth	0.14	0.01	0.18	0.28	3.04
921	old_town	0.00	0.00	0.00	0.41	1.57
916	old_town	0.17	0.04	0.80	0.55	0.62
900	eth	0.10	0.04	0.00	0.40	0.58
899	eth	0.08	0.03	0.00	0.05	0.34
921	old_town	0.08	0.03	0.30	0.40	1.52
916	old_town	0.11	0.04	0.92	1.01	1.99

You need: A long format

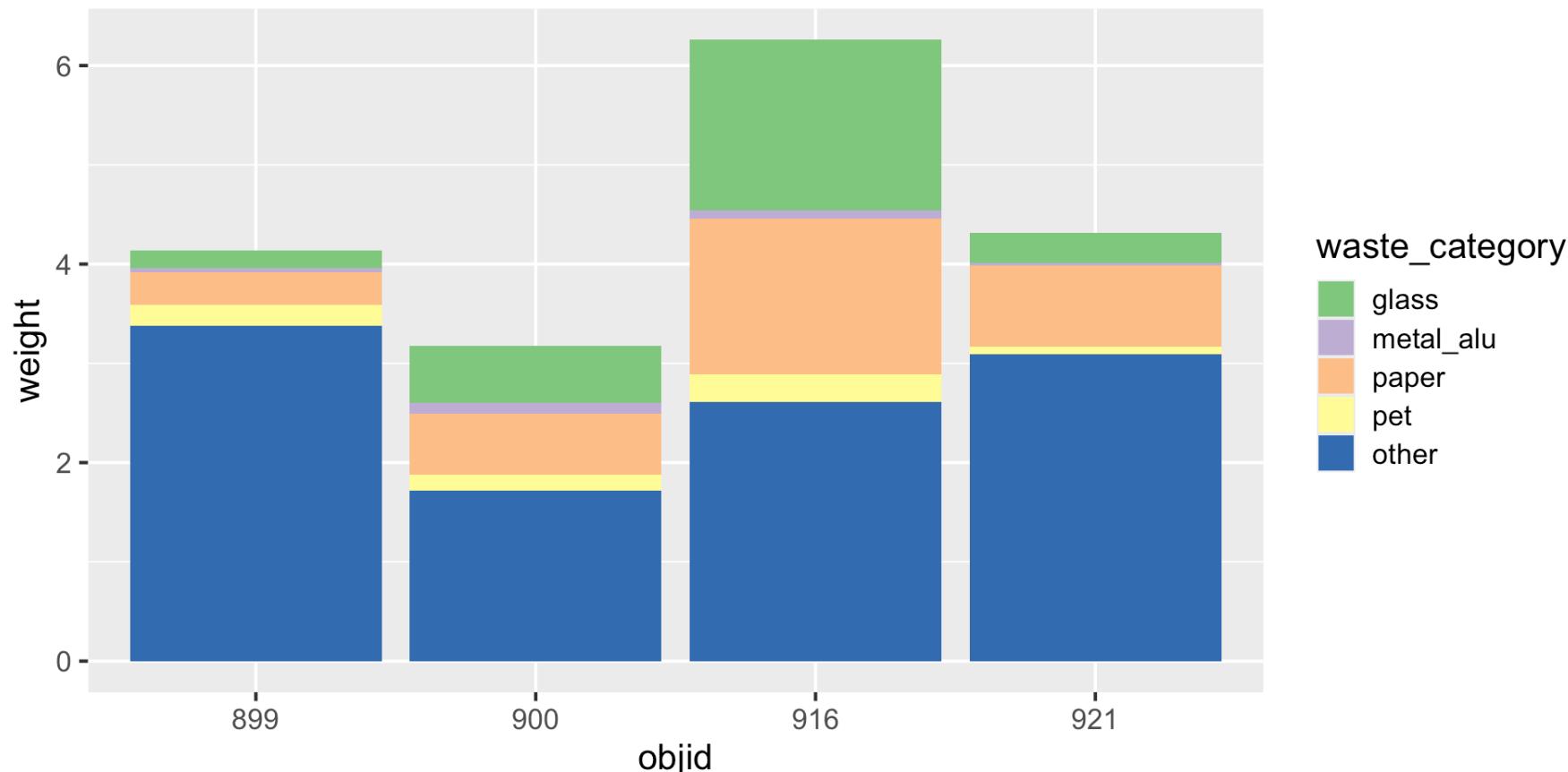
objid	location	waste_category	weight
900	eth	pet	0.06
900	eth	metal_alu	0.06
900	eth	glass	0.58
900	eth	paper	0.21
900	eth	other	1.14
899	eth	pet	0.14
899	eth	metal_alu	0.01
899	eth	glass	0.18
899	eth	paper	0.28
899	eth	other	3.04
921	old_town	pet	0.00
921	old_town	metal_alu	0.00
921	old_town	glass	0.00
921	old_town	@ rbtLfs25.github.io/website/	
921	old_town	paper	0.41

objid	location	waste_category	weight
921	old_town	other	1.57
916	old_town	pet	0.17
916	old_town	metal_alu	0.04
916	old_town	glass	0.80
916	old_town	paper	0.55
916	old_town	other	0.62
900	eth	pet	0.10
900	eth	metal_alu	0.04
900	eth	glass	0.00
900	eth	paper	0.40
900	eth	other	0.58
899	eth	pet	0.08
899	eth	metal_alu	0.03
899	eth	glass	0.00
899	eth	paper	0.05
899	eth	other	0.34

objid	location	waste_category	weight
921	old_town	pet	0.08
921	old_town	metal_alu	0.03
921	old_town	glass	0.30
921	old_town	paper	0.40
921	old_town	other	1.52
916	old_town	pet	0.11
916	old_town	metal_alu	0.04
916	old_town	glass	0.92
916	old_town	paper	1.01
916	old_town	other	1.99

Three variables -> three aesthetics

```
1 ggplot(data = waste_data_tidy,  
2         mapping = aes(x = objid,  
3                           y = weight,  
4                           fill = waste_category)) +  
5   geom_col() +  
6   scale_fill_brewer(type = "qual")
```



How to

```
1 waste_data_untidy
```

objid	location	pet	metal_alu	glass	paper	other
900	eth	0.06	0.06	0.58	0.21	1.14
899	eth	0.14	0.01	0.18	0.28	3.04
921	old_town	0.00	0.00	0.00	0.41	1.57
916	old_town	0.17	0.04	0.80	0.55	0.62
900	eth	0.10	0.04	0.00	0.40	0.58
899	eth	0.08	0.03	0.00	0.05	0.34
921	old_town	0.08	0.03	0.30	0.40	1.52
916	old_town	0.11	0.04	0.92	1.01	1.99

How to

```
1 waste_data_untidy |>
2   pivot_longer(cols = pet:other,
3                 names_to = "waste_category",
4                 values_to = "weight")
```

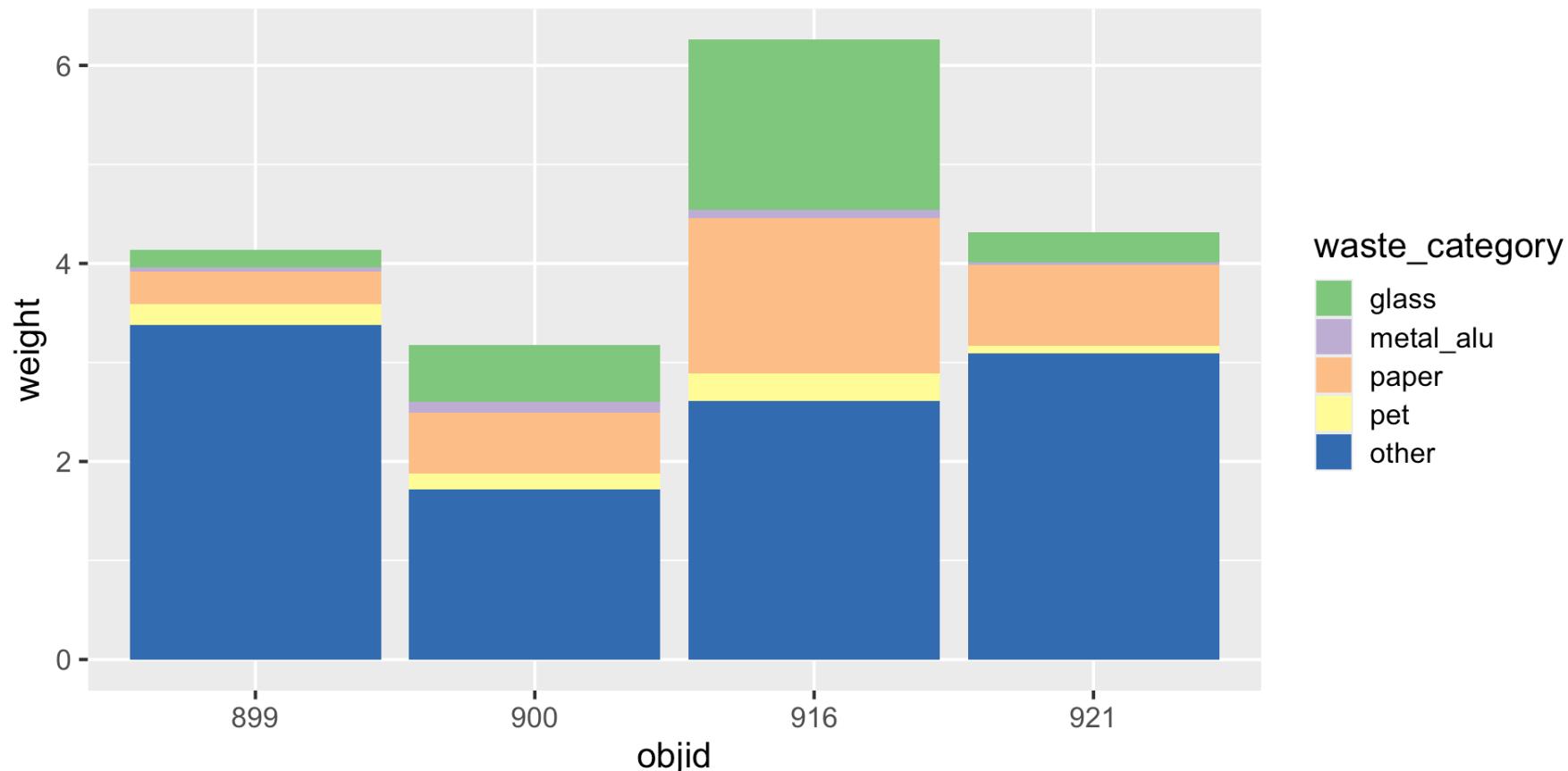
objid	location	waste_category	weight
900	eth	pet	0.06
900	eth	metal_alu	0.06
900	eth	glass	0.58
900	eth	paper	0.21
900	eth	other	1.14
899	eth	pet	0.14
899	eth	metal_alu	0.01
899	eth	glass	0.18
899	eth	paper	0.28
899	eth	other	3.04
921	old_town	pet	0.00

objid	location	waste_category	weight
921	old_town	metal_alu	0.00
921	old_town	glass	0.00
921	old_town	paper	0.41
921	old_town	other	1.57
916	old_town	pet	0.17
916	old_town	metal_alu	0.04
916	old_town	glass	0.80
916	old_town	paper	0.55
916	old_town	other	0.62
900	eth	pet	0.10
900	eth	metal_alu	0.04
900	eth	glass	0.00
900	eth	paper	0.40
900	eth	other	0.58
899	eth	pet	0.08
899	eth	metal_alu	0.03

objid	location	waste_category	weight
899	eth	glass	0.00
899	eth	paper	0.05
899	eth	other	0.34
921	old_town	pet	0.08
921	old_town	metal_alu	0.03
921	old_town	glass	0.30
921	old_town	paper	0.40
921	old_town	other	1.52
916	old_town	pet	0.11
916	old_town	metal_alu	0.04
916	old_town	glass	0.92
916	old_town	paper	1.01
916	old_town	other	1.99

Three variables -> three aesthetics

```
1 ggplot(data = waste_data_tidy,  
2         mapping = aes(x = objid,  
3                           y = weight,  
4                           fill = waste_category)) +  
5   geom_col() +  
6   scale_fill_brewer(type = "qual")
```



Homework assignments

module 6

Module 6 documentation

rbtl-fs25.github.io/website/modules/md-06.html

Module 6

Data types & Vectors & Pivoting

◎ Learning Objectives

1. Learners can identify different ways of accessing a vector from a dataframe
2. Learners can list the four main atomic vector types in R.
3. Learners can apply functions from the `tidyR` R Package to transform their data from a wide to a long format and vice versa.

Slides

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Data types & Vectors & Pivoting

Homework due date

- Homework assignment due: Wednesday, April 2nd

Wrap-up

Thanks! 🌻

Slides created via revealjs and Quarto:

<https://quarto.org/docs/presentations/revealjs/>

Access slides as [PDF on GitHub](#)

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References

Ben Aleya, Ali, Daniel Biek, Lin Boynton, Julia Jaeggi, Sebastian Camilo Loos, Chiara Meyer-Piening, Jonathan Olal Ogwang, et al. 2022. “Research Beyond the Lab, Spring Term 2022, Global Health Engineering, ETH Zurich. Raw Data and Analysis-Ready Derived Data on Waste Management in Public Spaces in Zurich, Switzerland.” Zenodo. <https://doi.org/10.5281/ZENODO.7331120>.