Data Validation in R

From Principles to Tools and Packages

Dr Caterina Constantinescu

Tesco Bank

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About me

caterina.constantinescu@gmail.com
https://datapowered.io/
@c__constantine
CaterinaC

- Data scientist @ Tesco Bank
- Background in psychology
- R user since 2012
- Ex-EdinbR organiser: @edinb_r EdinburghRusers
- Why data validation?

Outline

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What is data validation?

- Checking the quality of source data before importing or otherwise processing it
- More about the formal aspects of the data, rather than knowing it is necessarily 'correct'

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  - Data validity often can't be assessed formally
  - Classical Test Theory: `Observed score = True score + Error`
- Same as data cleaning? Not quite...
  - One-off, quick & dirty, fixes in the here and now, vs. robust, 'future-proofed' code that can anticipate the ways in which future data might be problematic
  - Flagging issues vs actually fixing them

Outline


WHEN YOU HAVE A CODING STANDARD TO IMPOSE
AND YOU HAVEN'T TOLD ANYONE FOR 5MIN.
memegenerator.net

Principles: Data validation

Steve McConnell's *Code complete* (`Defensive programming`)

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- Garbage in, garbage out (aka user beware)? Maybe not.
- A good program never puts out garbage, regardless what it takes in.
- Alternatives:
  - Garbage in, nothing out
  - Garbage in, error message out
  - No garbage allowed in

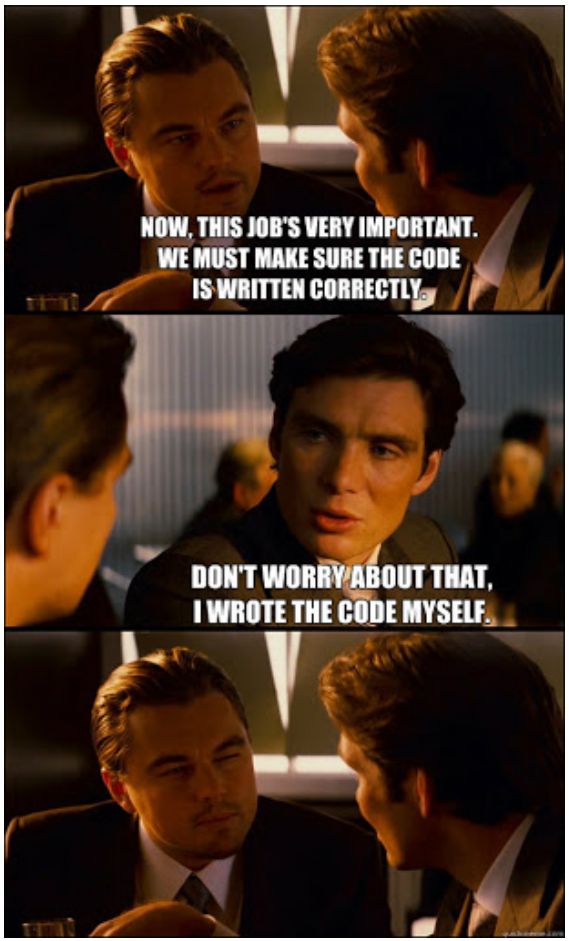
You can't make me...

Story time

Healthcare records

Story time

Date formats



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  - Replace illegal value with a 'neutral' value (zero/missing)
  - Substitute with closest legal value (e.g., winsorize)
  - Any of the above & append issue to a log that you can then make available in some way (if appropriate)
  - Display an error message to the user
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- When to use each?

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  - For conditions you *expect to occur* and *can foresee* (usually a result of bad input data)
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  - Often suitable for data coming in from external (less trusted) sources.

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- **For highly robust code, assert and then handle the error anyway.**

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The data science way:

- Error-handling
  - For conditions you *can't control* (but can potentially foresee, e.g., packages on which you depend may change; resources may be temporarily unavailable, wrong file encoding etc).
- Assertions
  - For conditions that should *not occur* - but can use this for untrusted data sources especially (not just flushing out errors).
  - Still act as documentation to make explicit any assumptions about what is normal
  - Not necessarily indicators that a new release is needed.
- Choice also depends on a correctness vs robustness trade-off.
- **For highly robust code, assert and then handle the error anyway.**

When/where to validate?

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- Relationship between barricades and assertions (the Code Complete way:)
  - Error handling outside the barricades, as less safe to make assumptions about the data
  - Assertions inside the barricade, as the data there should already be sanitised when it reaches them. Hence, any issues are more likely to mean the code itself is buggy, rather than that there are errors in the data (beware of domain-specific/data science differences)

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- Can fix (silently even), e.g., duplicated columns or cases, unnecessary columns, strip special characters.

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   - Class (e.g., integer, numeric, character)
   - Range (e.g., A number between 35-40)
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6. Cross datasets
   - If merges are required, correct overlap between keys

Outline

Example: Anscombe's quartet

`datasets::anscombe`

	x1	x2	x3	x4	y1	y2	y3	y4
1	10	10	10	8	8.04	9.14	7.46	6.58
2	8	8	8	8	6.95	8.14	6.77	5.76
3	13	13	13	8	7.58	8.74	12.74	7.71
4	9	9	9	8	8.81	8.77	7.11	8.84
5	11	11	11	8	8.33	9.26	7.81	8.47
6	14	14	14	8	9.96	8.10	8.84	7.04
7	6	6	6	8	7.24	6.13	6.08	5.25
8	4	4	4	19	4.26	3.10	5.39	12.50
9	12	12	12	8	10.84	9.13	8.15	5.56
10	7	7	7	8	4.82	7.26	6.42	7.91
11	5	5	5	8	5.68	4.74	5.73	6.89

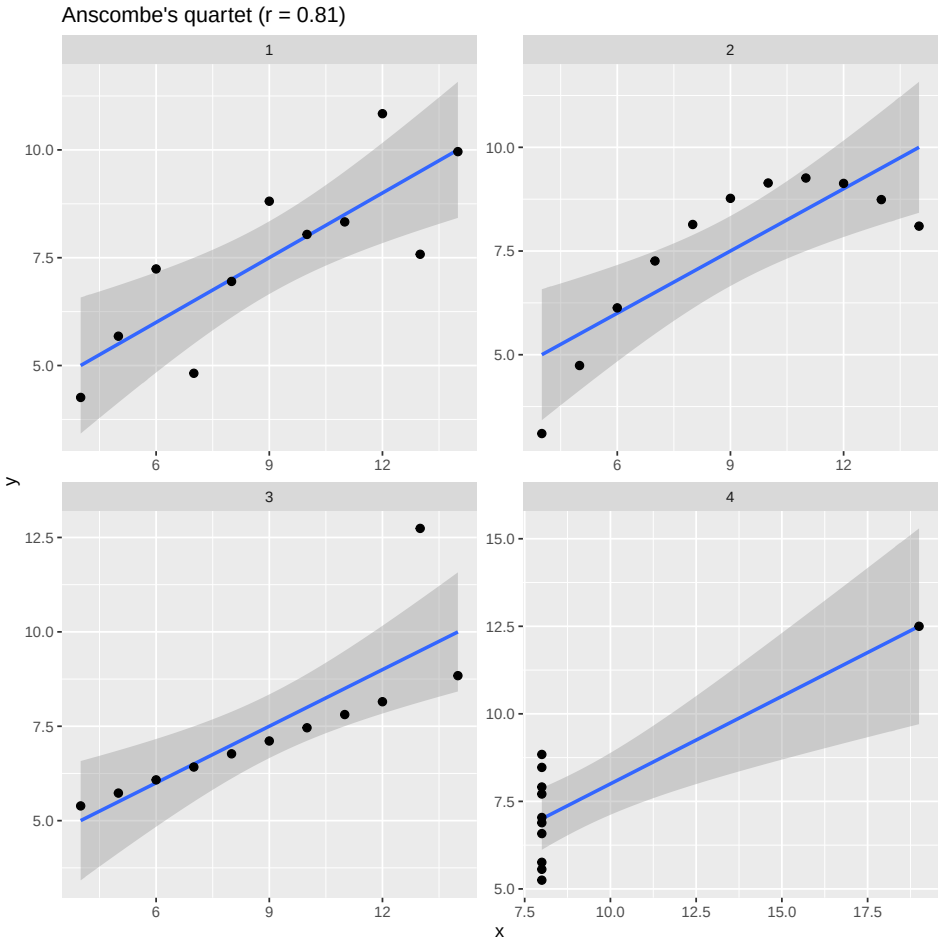
Example: Anscombe's quartet

```
Description
Four x-y datasets which have the same traditional statistical
properties (mean, variance, correlation, regression line, etc.),
yet are quite different.

Format
A data frame with 11 observations on 8 variables.

x1 == x2 == x3 the integers 4:14, specially arranged
x4 values 8 and 19
y1, y2, y3, y4 numbers in (3, 12.5) with mean 7.5 and sdev 2.03
```

Example: Anscombe's quartet



validate

validate

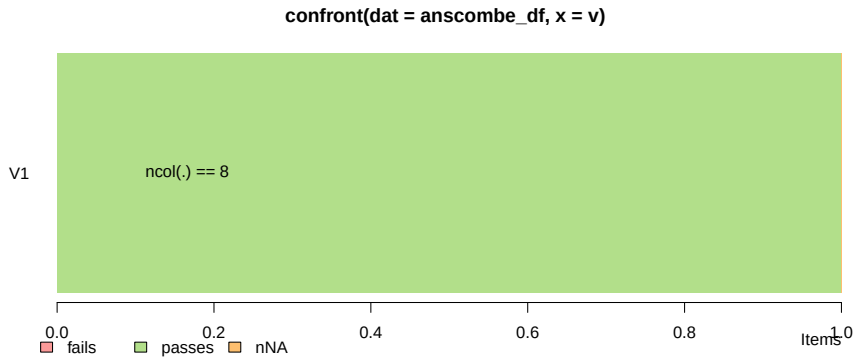
```
1  library(validate)
2  library(magrittr)
3
4  anscombe_df <- anscombe
5
6  anscombe_df %>%
7    check_that(
8        nrow(.) > 100 # Ooops!
9      , ncol(.) == 8
10     , is.numeric(x1)
11     , x1 == x2
12     , x1 == x3
13     , x2 == x4 # Ooops again!
14     , x4 %vin% c(8, 19)
15     , is_complete(x1, x2)
16     , cor1 := cor(x1, y1) %>% round(2)
17     , cor2 := cor(x2, y2) %>% round(2)
18     , cor1 == cor2
19     , m_y1 := mean(y1) %>% round(2)
20     , m_y1 == 7.5
21     , y1_sd := sd(y1) %>% round(2)
22     , y1_sd == 2.03) %>%
23   summary()
```

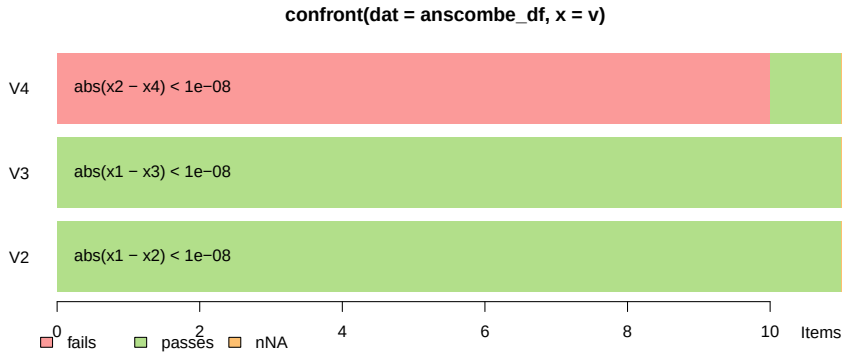
validate

	name	items	passes	fails	nNA	error	warning	expression
1	V01	1	0	1	0	FALSE	FALSE	nrow(.) > 100
2	V02	1	1	0	0	FALSE	FALSE	ncol(.) == 8
3	V03	1	1	0	0	FALSE	FALSE	is.numeric(x1)
4	V04	11	11	0	0	FALSE	FALSE	abs(x1 - x2) < 1e-08
5	V05	11	11	0	0	FALSE	FALSE	abs(x1 - x3) < 1e-08
6	V06	11	1	10	0	FALSE	FALSE	abs(x2 - x4) < 1e-08
7	V07	11	11	0	0	FALSE	FALSE	x4 %vin% c(8, 19)
8	V08	11	11	0	0	FALSE	FALSE	is_complete(x1, x2)
9	V11	1	1	0	0	FALSE	FALSE	cor(x1, y1) %>% round(2) == cor(x2, y2)...
10	V13	1	1	0	0	FALSE	FALSE	mean(y1) %>% round(2) == 7.5
11	V15	1	1	0	0	FALSE	FALSE	sd(y1) %>% round(2) == 2.03

validate

```
1  v <- validator( ncol(.) == 8
2                , x1 == x2
3                , x1 == x3
4                , x2 == x4 )
5  cf <- confront(anscombe_df, v)
6  plot(cf)
```





assertr

assertr + assertive

```
1  library(assertr)
2  library(assertive)
3
4  anscombe_df %>%
5    # whole df
6    verify(has_all_names("x1", "x2", "x3", "x4", "y1", "y2", "y3", "y4")) %>%
7    verify(nrow(.) == 11) %>%
8    verify(ncol(.) == 8) %>%
9    # specific values:
10   verify(x1 == x2) %>%
11   verify(x2 == x3) %>%
12   verify(is.numeric(x1)) %>%
13   verify(mean(y1) %>% round(2) == 7.5) %>%
14   verify(sd(y1) %>% round(2) == 2.03) %>%
15   verify(cor(x1, y1) %>% round(2) == cor(x2, y2) %>% round(2) ) %>%
16   # by column:
17   assert(within_bounds(4, 14), x1:x2) %>%
18   assert(in_set(8, 19), x4) %>%
19   insist(within_n_sds(4), x1) %>%
20   # by row:
21   assert_rows(num_row_NAs, in_set(0), everything()) %>%
22   assert_rows(col_concat, is_uniq, x1:x4) %>%
23   insist_rows(maha_dist, within_n_mads(10), everything()) %>%
24   # extending via assertive:
25   verify(assertive::is_linux())
```

assertr + assertive

	x1	x2	x3	x4	y1	y2	y3	y4
1	10	10	10	8	8.04	9.14	7.46	6.58
2	8	8	8	8	6.95	8.14	6.77	5.76
3	13	13	13	8	7.58	8.74	12.74	7.71
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assertr + assertive

```
1  anscombe_df %>%
2    chain_start() %>%
3    # whole df
4    verify(has_all_names("x1", "x2", "x3", "x4", "y1", "y2", "y3", "y4")) %>%
5    verify(nrow(.) == 12) %>% # Ooops!
6    verify(ncol(.) == 8) %>%
7    # specific values:
8    verify(x1 == x2) %>%
9    verify(x2 == x3) %>%
10   verify(is.numeric(x1)) %>%
11   verify(mean(y1) %>% round(2) == 7.5) %>%
12   verify(sd(y1) %>% round(2) == 2.03) %>%
13   verify(cor(x1, y1) %>% round(2) == cor(x2, y2) %>% round(2) ) %>%
14   # by column:
15   assert(within_bounds(4, 14), x1:x2) %>%
16   assert(in_set(8, 19), x4) %>%
17   insist(within_n_sds(4), x1) %>%
18   # by row:
19   assert_rows(num_row_NAs, in_set(0), everything()) %>%
20   assert_rows(col_concat, is_uniq, x1:x4) %>%
21   insist_rows(maha_dist, within_n_mads(10), everything()) %>%
22   # extras:
23   verify(assertive::is_windows()) %>% # Nope !
24   chain_end()
```

assertr + assertive

```
There are 2 errors across 2 verbs:
-
    verb redux_fn                predicate column index value
1 verify       NA           nrow(.) == 12     NA     1    NA
2 verify       NA assertive::is_windows()     NA     1    NA

Error: assertr stopped execution
```

ensurer

ensurer

```
1  library(ensurer)
2  library(data.table)
3
4  # Set rules & data template
5  ensure_df_dt <- ensures_that(any(is.data.frame(.), is.data.table(.)),
6                               ! any(is.na(.)))
7
8  anscombe_tmpl <- anscombe_df[FALSE, ]
9  ensure_as_template <- function(x, tpl){
10   ensure_that(x,
11               identical(names(.), names(tpl)),
12               identical(sapply(., class), sapply(tpl, class)),
13               err_desc = "Please check column names and types, and try again.")}
14
15 # Apply to data
16 anscombe_df %>%
17   ensure_df_dt %>%
18   ensure_as_template(anscombe_tmpl) %>%
19   ensure_that(nrow(.) == 11,
20               ncol(.) == 8) %>%
21   # continuing with assertr chain:
22   verify(x1 == x2) %>%
23   verify(x2 == x3) %>%
24   verify(mean(y1) %>% round(2) == 7.5)
```

ensurer

	x1	x2	x3	x4	y1	y2	y3	y4
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ensurer

```
anscombe_df %>%
  ensure_df_dt %>%
  ensure_as_template(anscombe_tmpl) %>%
  ensure_that(all(. > 200), err_desc = "Case(s) under 200!", # Oops !
              nrow(.) == 11,
              ncol(.) == 9) %>% # Oops again !
  # continuing with assertr chain:
  verify(x1 == x2) %>%
  verify(x2 == x3) %>%
  verify(mean(y1) %>% round(2) == 7.5)
```

ensurer

```
Error: conditions failed for call 'anscombe_df %>%
ensure_df_dt %>% ensure_as_template(anscombe_tmpl) %>% ':
 * all(. > 200)
 * ncol(.) == 9
 Description: Case(s) under 200!
```

checkr

checkr

```
1  library(checkr)
2
3  new_copy <- anscombe_df %>%
4    check_colnames(names(anscombe_tmpl), exclusive = TRUE, error = TRUE) %>%
5    check_ncol(ncol = 8, error = TRUE) %>%
6    check_nrow(nrow = 11, error = TRUE) %>%
7    check_classes("data.frame") # can't easily check individual col classes
8
9  another_new_copy <- check_data(anscombe_df,
10                                values = list(x1 = 10000, x2 = 10000, x3 = c(4, 14), x4 = 10000,
11                                              y1 = 10000, y2 = 10000, y3 = 10000, y4 = 10000),
12                                exclusive = TRUE,
13                                order = TRUE,
14                                nrow = 11L, # no ncol
15                                error = TRUE)
```

checkr

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10	7	7	7	8	4.82	7.26	6.42	7.91
11	5	5	5	8	5.68	4.74	5.73	6.89

checkr

```
1  library(checkr)
2
3  another_new_copy <- check_data(anscombe_df,
4                                 values = list(x1 = 10000, x2 = 10000, x3 = c(4, 10), # Ooops!
5                                               x4 = "",  # Ooops again!
6                                               y1 = 10000, y2 = 10000, y3 = 10000, y4 = 10000),
7                                 exclusive = TRUE,
8                                 order = TRUE,
9                                 nrow = 11L, # no ncol
10                                error = TRUE)
11
12 # Error: the values in column x3 of anscombe_df must lie between 4 and 10
13
14 # check_rbind(datasets::mtcars, datasets::mtcars)
15 # check_join(data1, data2, by = c(x = "y"), error = FALSE)
16 # check_key()
```

pointblank

pointblank

```
1  library(pointblank)
2
3  create_agent(anscombe_df) %>% # optional !
4    col_exists(names(anscombe)) %>%
5    col_schema_match(col_schema(.tbl = anscombe_tmpl)) %>%
6
7    col_vals_not_null(names(anscombe_tmpl)) %>%
8    col_vals_in_set(x4, c(8, 19)) %>%
9    col_vals_between(x1, 4, 14) %>%
10
11   col_vals_expr(expr(nrow(.) == 11)) %>%
12   col_vals_expr(expr(ncol(.) == 8)) %>%
13
14   col_vals_expr(expr(x1 == x2)) %>%
15   col_vals_expr(expr(x1 == x3)) %>%
16   col_vals_expr(expr(mean(y1) %>% round(2) == 7.5)) %>%
17   col_vals_expr(expr(cor(x1, y1) %>% round(2) == cor(x2, y2) %>% round(2))) %>%
18   interrogate() # optional !
```

pointblank

Pointblank Validation

agent_2020-10-20_20:15:28 (2020-10-20 20:15:29)

	STEP	COLUMNS	VALUES	TBL	EVAL	UNITS	PASS	FAIL	W	S	N	EXT
1	col_exists()	x1	—		✓	1	1 1.00	0 0.00	—	—	—	—
2	col_exists()	x2	—		✓	1	1 1.00	0 0.00	—	—	—	—
3	col_exists()	x3	—		✓	1	1 1.00	0 0.00	—	—	—	—
4	col_exists()	x4	—		✓	1	1 1.00	0 0.00	—	—	—	—
5	col_exists()	y1	—		✓	1	1 1.00	0 0.00	—	—	—	—
6	col_exists()	y2	—		✓	1	1 1.00	0 0.00	—	—	—	—
7	col_exists()	y3	—		✓	1	1 1.00	0 0.00	—	—	—	—
8	col_exists()	y4	—		✓	1	1 1.00	0 0.00	—	—	—	—
9	col_schema_match()	—	SCHEMA R TYPES		✓	1	1 1.00	0 0.00	—	—	—	—
10	col_vals_not_null()	x1	—		✓	11	11 1.00	0 0.00	—	—	—	—
11	col_vals_not_null()	x2	—		✓	11	11 1.00	0 0.00	—	—	—	—

pointblank

16	col_vals_not_null()	y3	—	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
17	col_vals_not_null()	y4	—	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
18	col_vals_in_set()	x4	8, 19	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
19	col_vals_between()	x1	[4, 14]	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
20	col_vals_expr()	—	nrow(.) == 11	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
21	col_vals_expr()	—	ncol(.) == 8	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
22	col_vals_expr()	—	x1 == x2	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
23	col_vals_expr()	—	x1 == x3	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
24	col_vals_expr()	—	mean(y1) %>% r…	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
25	col_vals_expr()	—	cor(x1, y1) %>…	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—

pointblank

```
1  anscombe_df %>%
2  col_exists(names(anscombe_tmpl)) %>%
3  col_schema_match(col_schema(.tbl = anscombe_tmpl)) %>%
4
5  col_vals_not_null(names(anscombe_tmpl)) %>%
6  col_vals_in_set(x4, c(8, 19)) %>%
7  col_vals_between(x1, 4, 10) %>% # Ooops !
8
9  col_vals_expr(expr(nrow(.) == 60)) %>% # Oops again !
10 col_vals_expr(expr(ncol(.) == 8)) %>%
11
12 col_vals_expr(expr(x1 == x2)) %>%
13 col_vals_expr(expr(x1 == x3)) %>%
14 col_vals_expr(expr(mean(y1) %>% round(2) == 7.5)) %>%
15 col_vals_expr(expr(cor(x1, y1) %>% round(2) == cor(x2, y2) %>% round(2)))
```

pointblank

```
 +   col_vals_expr(expr(cor(x1, y1) %>% round(2) == cor(x2, y2) %>% round(2))) # %>%
Error: Exceedance of failed test units where values in ‘x1‘ should have been
between ‘4‘ and ‘10‘.
The ‘col_vals_between()‘ validation failed beyond the absolute threshold level (1).
* failure level (4) >= failure threshold (1)
```

pointblank

If re-adding `create_agent()` + `interrogate()`

16	col_vals_not_null()	y3	—	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
17	col_vals_not_null()	y4	—	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
18	col_vals_in_set()	x4	8, 19	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
19	col_vals_between()	x1	[4, 10]	ℐ	✓	11	7 0.64	4 0.36	—	—	—	CSV
20	col_vals_expr()	—	nrow(.) == 60	ℐ	✓	11	0 0.00	11 1.00	—	—	—	CSV
21	col_vals_expr()	—	ncol(.) == 8	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
22	col_vals_expr()	—	x1 == x2	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
23	col_vals_expr()	—	x1 == x3	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
24	col_vals_expr()	—	mean(y1) %>% r…	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—
25	col_vals_expr()	—	cor(x1, y1) %>…	ℐ	✓	11	11 1.00	0 0.00	—	—	—	—

ruler

ruler

```
1  library(ruler)
2  anscombe_dims_rules <- . %>%
3    dplyr::summarise(nrow = nrow(.) == 11,
4                     ncol = ncol(.) == 8)
5
6  anscombe_na_rules <- . %>% dplyr::summarise(all_not_na = Negate(anyNA)(.))
7
8  anscombe_class_rules <- . %>% dplyr::summarise_at(vars(names(anscombe_df)), rules(is.numeric(.)))
9
10 anscombe_data_pack <- data_packs(data_nrow = anscombe_dims_rules,
11                                  data_na = anscombe_na_rules,
12                                  data_classes = anscombe_class_rules)
13
14 x1_value_rules <- . %>% dplyr::transmute_at(c("x1"), rules(. %in% 4:14))
15 x4_value_rules <- . %>% dplyr::transmute_at(c("x4"), rules(. %in% c(8, 19)))
16 y1_value_rules <- . %>% dplyr::transmute_at(c("y1"), rules(y1_mean = mean(.) %>% round(2) == 7.5))
17
18 anscombe_cell_packs <- cell_packs(x1_test = x1_value_rules,
19                                   x4_test = x4_value_rules,
20                                   y1_test = y1_value_rules)
21
22 anscombe_df %>%
23   expose(anscombe_data_pack, .remove_obeyers = TRUE) %>%
24   expose(anscombe_cell_packs, .remove_obeyers = TRUE) %>% # get_report() %>% # or:
25   assert_any_breaker()
```

ruler

	x1	x2	x3	x4	y1	y2	y3	y4
1	10	10	10	8	8.04	9.14	7.46	6.58
2	8	8	8	8	6.95	8.14	6.77	5.76
3	13	13	13	8	7.58	8.74	12.74	7.71
4	9	9	9	8	8.81	8.77	7.11	8.84
5	11	11	11	8	8.33	9.26	7.81	8.47
6	14	14	14	8	9.96	8.10	8.84	7.04
7	6	6	6	8	7.24	6.13	6.08	5.25
8	4	4	4	19	4.26	3.10	5.39	12.50
9	12	12	12	8	10.84	9.13	8.15	5.56
10	7	7	7	8	4.82	7.26	6.42	7.91
11	5	5	5	8	5.68	4.74	5.73	6.89

ruler

```
1  y1_value_rules <- . %>% dplyr::transmute_at(c("y1"), rules(y1_mean = mean(.) %>% round(2) == 7.8)) # Ooops!
2
3
4  anscombe_cell_packs <- cell_packs(x1_test = x1_value_rules,
5                                    x4_test = x4_value_rules,
6                                    y1_test = y1_value_rules)
7
8
9  anscombe_df %>%
10   expose(anscombe_data_pack, .remove_obeyers = TRUE) %>%
11   expose(anscombe_cell_packs, .remove_obeyers = TRUE) %>%
12   get_report() # or assert_any_breaker()
```

ruler

```
# get_report() or assert_any_breaker()
  Breakers report
Tidy data validation report:
# A tibble: 11 x 5
   pack    rule    var      id value
   <chr>   <chr>   <chr> <int> <lgl>
 1 y1_test y1_mean ""        1 FALSE
 2 y1_test y1_mean ""        2 FALSE
 3 y1_test y1_mean ""        3 FALSE
 4 y1_test y1_mean ""        4 FALSE
 5 y1_test y1_mean ""        5 FALSE
 6 y1_test y1_mean ""        6 FALSE
 7 y1_test y1_mean ""        7 FALSE
 8 y1_test y1_mean ""        8 FALSE
 9 y1_test y1_mean ""        9 FALSE
10 y1_test y1_mean ""       10 FALSE
11 y1_test y1_mean ""       11 FALSE

Error: assert_any_breaker: Some breakers found in exposure.
```

checkmate

checkmate

```
1  library(checkmate)
2
3  anscombe_df %>%
4    assert_data_frame(types = lapply(anscombe_tmpl, class) %>% unlist(),
5                      any.missing = FALSE,
6                      nrows = 11,
7                      ncols = 8) # returns output invisibly if successful
8
9  anscombe_df %>%
10   names() %>%
11   assertNames(permutation.of = names(anscombe_tmpl))
12
13 assertTRUE(with(anscombe_df, identical(x1, x2)))
14 assertSetEqual(anscombe_df$x4, c(8, 19))
15 assertTRUE(with(anscombe_df,
16                 identical(cor(x1, y1) %>% round(2),
17                           cor(x2, y2) %>% round(2))))
```

checkmate

```
1  library(checkmate)
2
3  anscombe_df %>%
4    assert_data_frame(types = lapply(anscombe_tmpl, class) %>% unlist(),
5                      any.missing = FALSE,
6                      nrows = 12,
7                      ncols = 8)
8  # Error in function_list[[k]](value) :
9  #  Assertion on '.' failed: Must have exactly 12 rows, but has 11 rows.
10
11 anscombe_df %>%
12   names() %>%
13   assertNames(permutation.of = names(mtcars))
14 # Error in function_list[[k]](value) :
15 #  Assertion on '.' failed: Must be a permutation of set {mpg,cyl,disp,hp,drat,wt,qsec,vs,am,gear,carb}.
16
17 assertTRUE(with(anscombe_df, identical(x1, x4)))
18 # Error: Assertion on 'with(anscombe_df, identical(x1, x4))' failed: Must be TRUE.
```

Outline

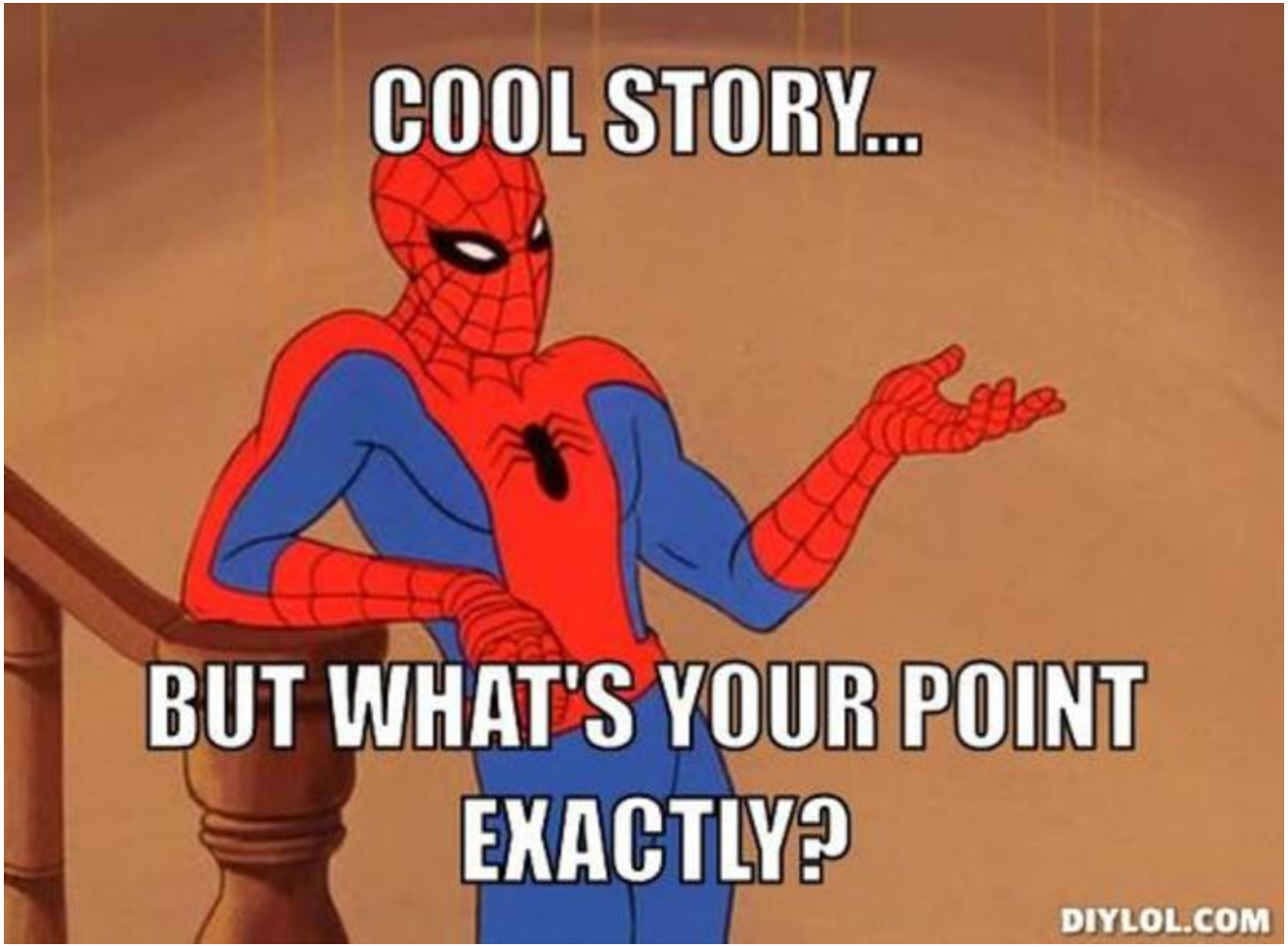
readr::read_csv + readr:::n_problems

```
1  library(readr)
2  inputPath <- "/home/caterina/Desktop/anscombe.csv"
3
4  anscombe_upload <- read_csv(file = inputPath,
5                              col_types = list(
6                                x1 = col_double(), x2 = col_double(), x3 = col_double(), x4 = col_double(),
7                                y1 = col_double(), y2 = col_date(), # !!!
8                                y3 = col_double(), y4 = col_double()))
9
10 if (readr:::n_problems(anscombe_upload) > 0) {
11
12   pbs <- problems(anscombe_upload)
13   surface_parsing_errs <- paste0("Found ",
14                                  nrow(pbs),
15                                  " parsing error(s) in column(s): '",
16                                  paste(unique(pbs$col), collapse = "' & '"),
17                                  "'. Please check the upload, correct any problematic values and try again.")
18   anscombe_upload <- surface_parsing_errs
19
20 } else {
21    anscombe_upload # continue with extra processing, checking, etc
22 }
```

readr::read_csv + readr:::n_problems

```
>  problems(anscombe_upload)
# A tibble: 11 x 5
     row col   expected     actual file
   <int> <chr> <chr>        <chr>  <chr>
 1     1 y2    "date like " 9.14   '/home/caterina/Desktop/anscombe.csv'
 2     2 y2    "date like " 8.14   '/home/caterina/Desktop/anscombe.csv'
 3     3 y2    "date like " 8.74   '/home/caterina/Desktop/anscombe.csv'
 4     4 y2    "date like " 8.77   '/home/caterina/Desktop/anscombe.csv'
 5     5 y2    "date like " 9.26   '/home/caterina/Desktop/anscombe.csv'
 6     6 y2    "date like " 8.1    '/home/caterina/Desktop/anscombe.csv'
 7     7 y2    "date like " 6.13   '/home/caterina/Desktop/anscombe.csv'
 8     8 y2    "date like " 3.1    '/home/caterina/Desktop/anscombe.csv'
 9     9 y2    "date like " 9.13   '/home/caterina/Desktop/anscombe.csv'
10    10 y2    "date like " 7.26   '/home/caterina/Desktop/anscombe.csv'
11    11 y2    "date like " 4.74   '/home/caterina/Desktop/anscombe.csv'
```

Outline


COOL STORY...
BUT WHAT'S YOUR POINT EXACTLY?
DIYLOL.COM

Conclusions

- Discussed packages/tools:
  - `validate`
  - `assertr` (`assertive`)
  - `ensurer`
  - `checkr`
  - `pointblank`
  - `ruler`
  - `checkmate`
  - `read_csv` / `n_problems`

  But... no "one-stop shop" - it's OK/necessary to customise

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  But... no "one-stop shop" - it's OK/necessary to customise

- Data validation teaches you to think defensively: code *into* a language, not *in* it
- Allows you to build more robust code
- Forces you to think more deeply about your assumptions/ check your own understanding of the data
- Supports collaboration

Thanks!