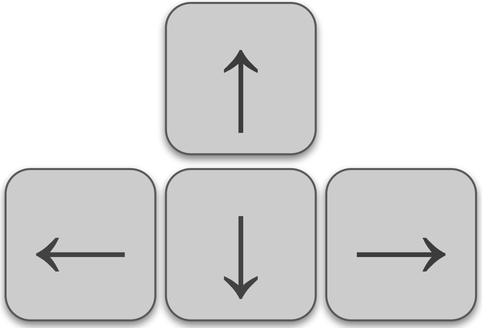
```
{“talk_title": “Column Names as Contracts”,

 “talk_author”: {
   “author_name”: “Emily Riederer”,
   “author_twtr”: “@emilyriederer”,
   “author_site”: “emily.rbind.io”
  },
 “talk_forum”: {
   “forum_name”: “Data Workshop on Reproducibility”,
   “forum_locn”: “Toronto”,
   “forum_date”: “2021-02-26”
  }

}
```

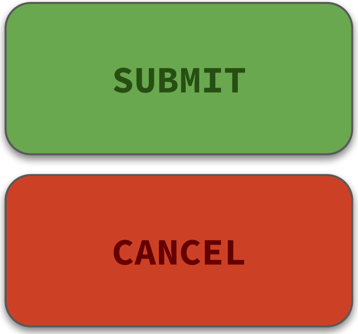
User interfaces make performance contracts

Universal Symbols

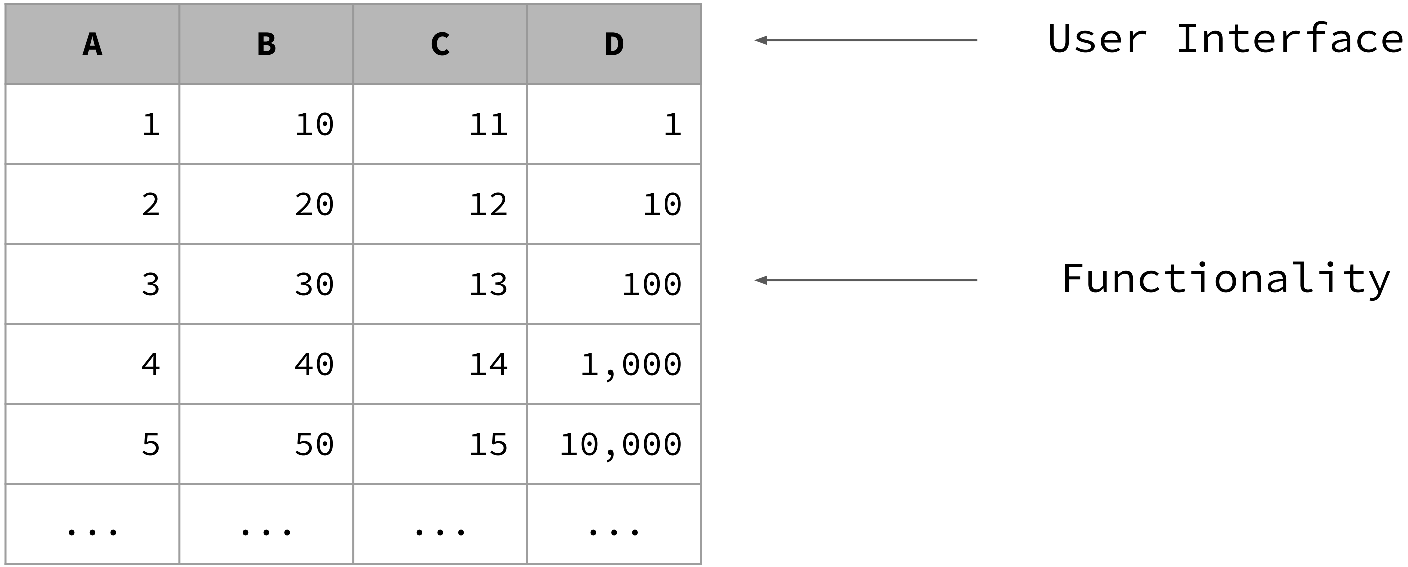
Grouping



Aesthetics



Column names are the user interface of our data



A	B	C	D
1	10	11	1
2	20	12	10
3	30	13	100
4	40	14	1,000
5	50	15	10,000
...	...	...	...

User Interface

Functionality

Subtle design choices challenge scientific (re)producibility

Origin	Encoding	Usage
Field provenance	Indicator encoding	Feature leakage
When field loads	Metric definition	Date formats
Unique keys	Null handling	Allowed operations

Subtle design choices challenge scientific (re)producibility

Indicator encoding

“We had **a bunch of zeros that should have been coded ones** and the ones should have been coded zeroes.”

Retraction Watch

Metric definition

“These data sets often have multiple files that...have **unclear and sometimes duplicative variables**. Such complexities are commonplace among many data systems... I would not be surprised if coding errors were fairly common, and that the ones discovered constitute only the “tip of the iceberg.”
”

Retraction Watch

Column names rarely encode human-interpretable meaning

US Census Bureau

B19013_001 (median household income)
P013001 (median age)

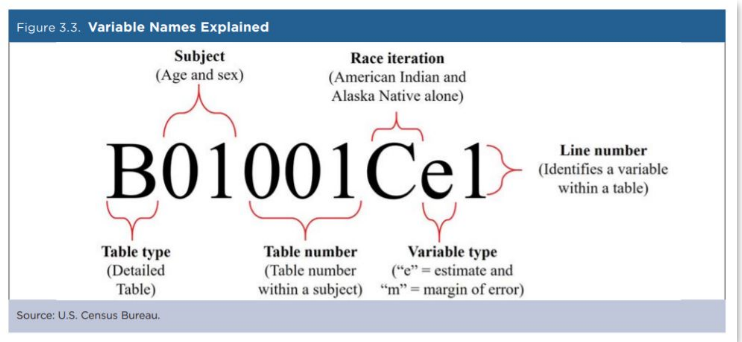


Figure 3.3. **Variable Names Explained**

Source: U.S. Census Bureau.

Column names rarely encode human-interpretable meaning

US Census Bureau

B19013_001 (median household income)
P013001 (median age)

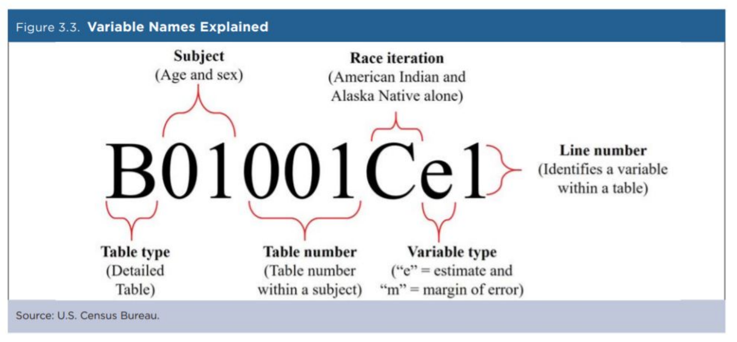


Figure 3.3. **Variable Names Explained**

Source: U.S. Census Bureau.

Cooperative Congressional Election Study

year
case_id
st
st_post
cd_up
cd_up_post
gender
age
educ
race
hispanic
citizen
religion
marstat
ownhome
has_child
no_milstat
faminc
employ
union
economy_retro
newsint
approval_pres
approval_gov
approval_sen1
approval_sen2

Indicator?
Categorical?
Continuous?

Same type,
different
conventions

Numeric or
binary?

Column names are a way to align data producers and consumers

From lab assistant

to PI’s desk

From you in the field

to you in the office

From the paper author

to the replicator

From the data engineer

to the analyst

Using controlled vocabularies for column names

WHAT

1. Establish a set of well-defined stubs
2. Stubs at different levels encode different semantics
3. Stubs may also carry associated contracts
4. Stubs are composed to communicate complex concepts

An example vocabulary

Stub
ID
IND / IS
BIN
N
AMT
VAL
DT
TM
CAT
CD

An example vocabulary

Stub	Semantics
`ID`	Unique entity identifier
`IND / IS`	Binary 0/1 indicator; rest of name describes 1 condition
`BIN`	Binary 0/1 indicator; rest of name describes 1 condition
`N`	Count of quantity or event occurrences
`AMT`	Sum-able real number amount (“denominator free”)
`VAL`	Numeric variables that are not inherently summable
`DT`	Date of an event
`TM`	Timestamp of an event
`CAT`	Human-readable categorical variable
`CD`	System-generated categorical variable

An example vocabulary

Stub	Semantics	Contracts
ID	Unique entity identifier	Numeric, primary / surrogate key
IND / IS	Binary 0/1 indicator; rest of name describes 1 condition	Always 0 or 1, non-null
BIN	Binary 0/1 indicator; rest of name describes 1 condition	Always 0 or 1
N	Count of quantity or event occurrences	Non-negative integer, non-null
AMT	Sum-able real number amount (“denominator free”)	Numeric
VAL	Numeric variables that are not inherently summable	Numeric
DT	Date of an event	Date, ISO 8601 (YYYY-MM-DD)
TM	Timestamp of an event	Datetime, YYYY-MM-DD HH:MM:SS
CAT	Human-readable categorical variable	-
CD	System-generated categorical variable	-

An example vocabulary

Stub	Semantics	Contracts
`ID`	Unique entity identifier	Numeric, primary / surrogate key
`IND / IS`	Binary 0/1 indicator; rest of name describes 1 condition	Always 0 or 1, **non-null**
`BIN`	Binary 0/1 indicator; rest of name describes 1 condition	Always 0 or 1
`N`	Count of quantity or event occurrences	Non-negative integer, non-null
`AMT`	Sum-able real number amount (“denominator free”)	Numeric
`VAL`	Numeric variables that are **not inherently summable**	Numeric
`DT`	Date of an event	Date, **ISO 8601** (YYYY-MM-DD)
`TM`	Timestamp of an event	Datetime, YYYY-MM-DD HH:MM:SS
`CAT`	Human-readable categorical variable	-
`CD`	System-generated categorical variable	-

An example vocabulary

Stub
COUNTY
CASE
HOSP
...

An example vocabulary

Stub	**Semantics**
COUNTY	Continental US county or county equivalents as defined by the US Census Bureau
CASE	Test-confirmed COVID-19 case as reported by state health department and as aligned by date of testing
HOSP	In-patient COVID-19 hospitalization as reported by the state health department
...	

An example vocabulary

Stub	**Semantics**
COUNTY	Continental US county or county equivalents as defined by the US Census Bureau
CASE	**Test-confirmed** COVID-19 case as reported by state health department and as aligned by **date of testing**
HOSP	In-patient COVID-19 hospitalization as reported by the state health department
...	

An example vocabulary

Stub	Semantics	Consequence
COUNTY	Continental US county or county equivalents as defined by the US Census Bureau	
CASE	**Test-confirmed** COVID-19 case as reported by state health department and as aligned by **date of testing**	Reports may continue to **backfill**, generally up to 7 days
HOSP	In-patient COVID-19 hospitalization as reported by the state health department	
...		

An example vocabulary

Types
ID
IND / IS
BIN
N
AMT
VAL
DT
TM
CAT
...

X

Subjects
COUNTY
STATE
CASE
HOSP
...

X

Details
METRO
HPSA
ACTL
PRED
...

DT_COUNTY

ID_{COUNTY | STATE}

{DT | IND | PROP}_COUNTY_HPSA

IND_COUNTY_METRO

N_CASE_{ACTL | PRED}_{07|14|21|24}

N_HOSP_{ACTL | PRED}_{07|14|21|24}

...

Subtle design choices *aid* scientific (re)producibility

Origin

Field provenance

In ‘entity’ level

When field loads

In ‘entity’ level

Unique keys

ID field

Encoding

Indicator encoding

IND stub -> positive

Metric definition

Clearly composed

Null handling

Non-null guarantees

Usage

Feature leakage

select(data, -contains(“POST”))

Date formats

DT stub -> ISO8601

Allowed operations

VAL stub -> not summable

Using controlled vocabularies for column names

WHAT

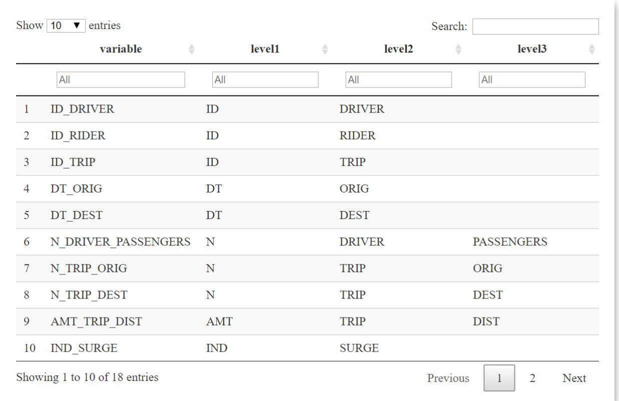
1. Establish a set of stubs with well-defined meanings
2. Stubs at different levels can encode different semantics
3. Stubs may also carry associated contracts
4. Stubs are composed to communicate complex concepts

WHY

- Automate maintenance burden for producers
- Reduce cognitive load for consumers
- Add clarity for reviewers

Data discoverability & documentation

Data dictionary



Show 10 entries

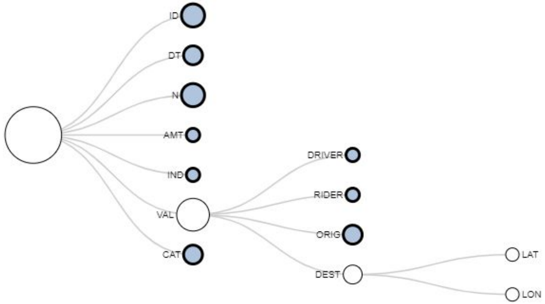
Search:

	variable	level1	level2	level3
	All	All	All	All
1	ID_DRIVER	ID	DRIVER	
2	ID_RIDER	ID	RIDER	
3	ID_TRIP	ID	TRIP	
4	DT_ORIG	DT	ORIG	
5	DT_DEST	DT	DEST	
6	N_DRIVER_PASSENGERS	N	DRIVER	PASSENGERS
7	N_TRIP_ORIG	N	TRIP	ORIG
8	N_TRIP_DEST	N	TRIP	DEST
9	AMT_TRIP_DIST	AMT	TRIP	DIST
10	IND_SURGE	IND	SURGE	

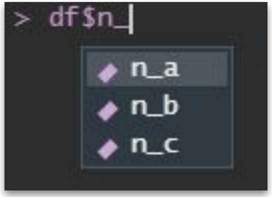
Showing 1 to 10 of 18 entries

Previous 1 2 Next

Variable exploration



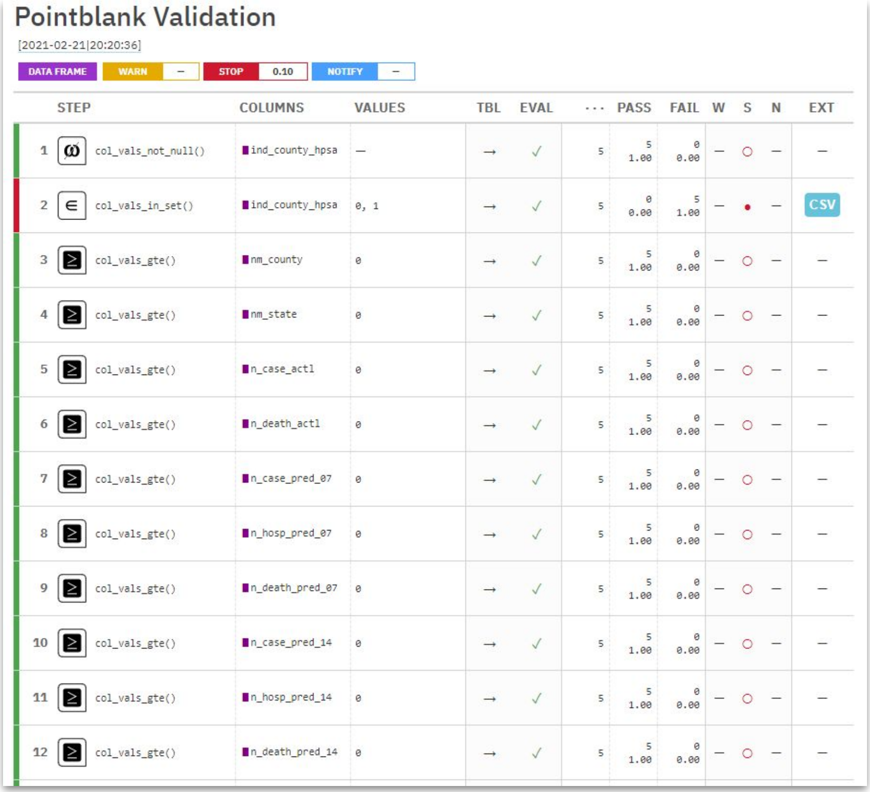
Autocomplete



```
> df$n_
```

Data validation

```
library(pointblank)

data %>%

  create_agent(actions =

                    action_levels(stop_at = 0.1)) %>%

  col_vals_gte(starts_with("N"), 0) %>%

  col_vals_not_null(starts_with("IND")) %>%

  col_vals_in_set(starts_with("IND"), c(0,1)) %>%

  col_is_date(starts_with("DT")) %>%

   interrogate()
```



Pointblank Validation

[2021-02-21|20:20:36]

DATA FRAME | WARN — | STOP 0.10 | NOTIFY —

	STEP	COLUMNS	VALUES	TBL	EVAL	···	PASS	FAIL	W	S	N	EXT
1	col_vals_not_null()	ind_county_hpsa	—	→	✓	5	5 1.00	0 0.00	—	○	—	—
2	∈ col_vals_in_set()	ind_county_hpsa	0, 1	→	✓	5	0 0.00	5 1.00	—	●	—	CSV
3	≥ col_vals_gte()	nm_county	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
4	≥ col_vals_gte()	nm_state	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
5	≥ col_vals_gte()	n_case_actl	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
6	≥ col_vals_gte()	n_death_actl	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
7	≥ col_vals_gte()	n_case_pred_07	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
8	≥ col_vals_gte()	n_hosp_pred_07	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
9	≥ col_vals_gte()	n_death_pred_07	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
10	≥ col_vals_gte()	n_case_pred_14	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
11	≥ col_vals_gte()	n_hosp_pred_14	0	→	✓	5	5 1.00	0 0.00	—	○	—	—
12	≥ col_vals_gte()	n_death_pred_14	0	→	✓	5	5 1.00	0 0.00	—	○	—	—

Data wrangling

```
library(dplyr)

data %>%

  group_by(NM_STATE) %>%

  summarize(

    across(starts_with("IND"), mean),

    across(contains("_ACTL_"), sum)

  )
```

```
#> # A tibble: 51 x 4

#>   NM_STATE     IND_COUNTY_HPSA  N_CASE_ACTL  N_DEATH_ACTL

#>   <chr>                  <dbl>        <dbl>        <dbl>

#> 1 Alabama               0.149       455582        7566

#> 2 Alaska                0.235        51338         250

 #> 3 Arizona             0            753379       13098
```

Data wrangling

```
library(dplyr)

data %>%

  group_by(NM_STATE) %>%

  summarize(

    across(starts_with("IND"), mean),

    across(contains("_ACTL_"), sum)

  )
```

```
#>   NM_STATE      IND_COUNTY_HPSA  N_CASE_ACTL  N_DEATH_ACTL

#>   <chr>                   <dbl>        <dbl>         <dbl>

#> 1 Alabama                 0.149       455582          7566

#> 2 Alaska                  0.235        51338           250

 #> 3 Arizona               0            753379         13098
```

```
import pandas as pd

cols_n = [vbl for vbl in data.columns if vbl[0:2] == 'IND_']

cols_grp = ["NM_STATE"]

data.groupby(cols_grp)[cols_n].mean()
```

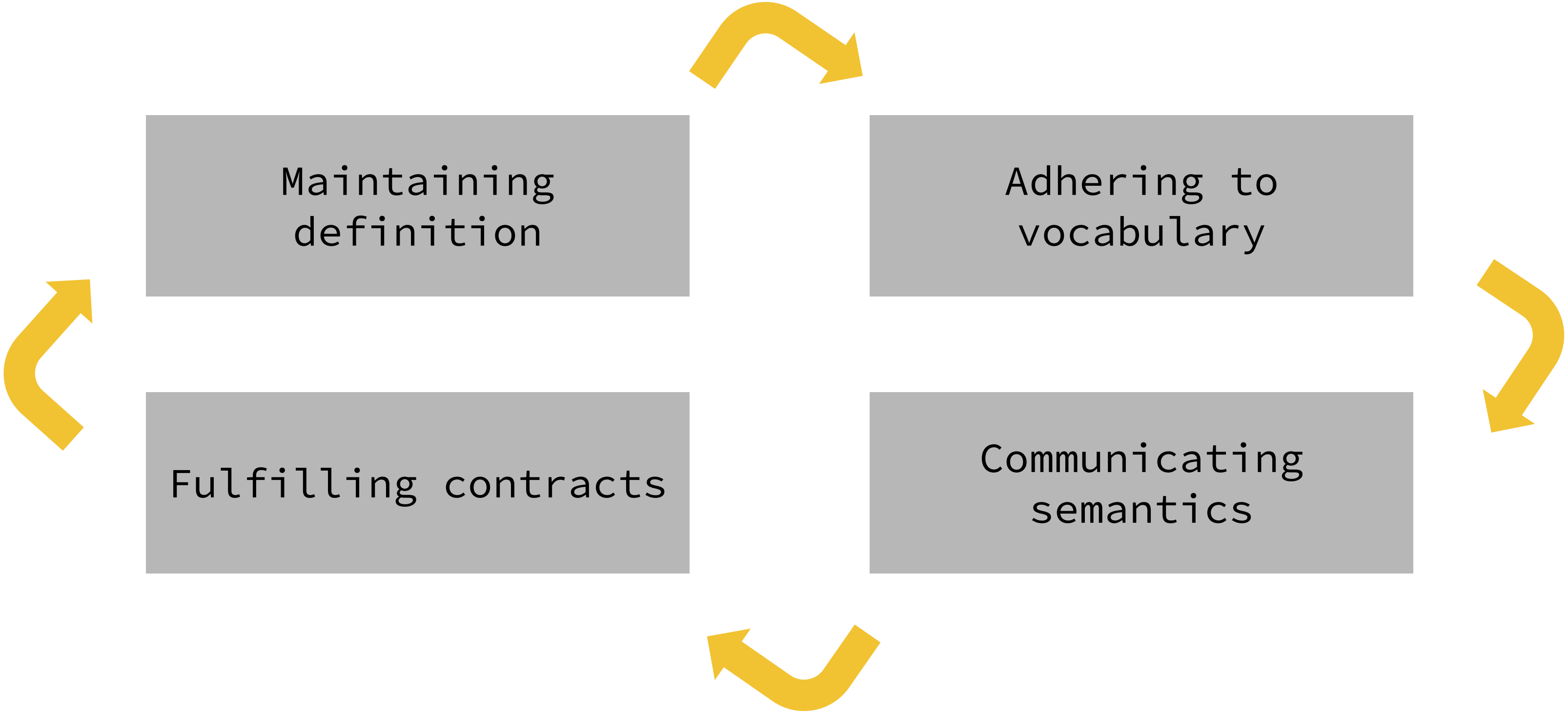
```
#>               IND_COUNTY_HPSA

#>  NM_STATE

#> Alabama                 0.149

#> Alaska                  0.235

#> Arizona               0
```

Data wrangling

```r
library(dplyr)

data %>%

  group_by(NM_STATE) %>%

  summarize(

    across(starts_with("IND"), mean, .names = "{gsub('IND', 'PROP', {.col})}"))

    across(contains("_ACTL_"), sum)

  )
```

```
#> # A tibble: 51 x 4

#>   NM_STATE     PROP_COUNTY_HPSA  N_CASE_ACTL  N_DEATH_ACTL

#>   <chr>                   <dbl>        <dbl>        <dbl>

#> 1 Alabama                 0.149       455582         7566

#> 2 Alaska                  0.235        51338          250

 #> 3 Arizona               0           753379        13098
```

Bad contracts are worse than not contracts



Maintaining definition

Adhering to vocabulary

Communicating semantics

Fulfilling contracts

Automated tools can help us uphold contracts

R package

define & evaluate convo

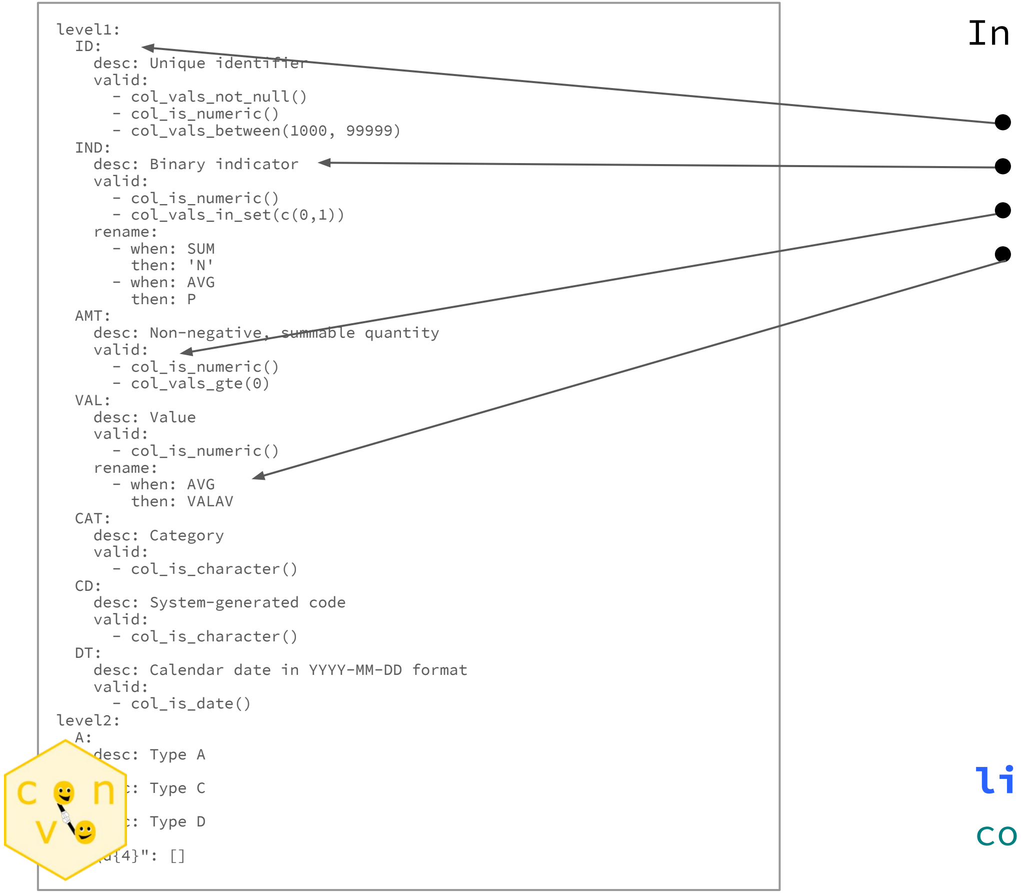
local data

brings coding practices to SQL

templates, macros, tests

data in RDBMS

Describe a controlled vocabularies with YAML



```yaml
level1:
  ID:
    desc: Unique identifier
    valid:
      - col_vals_not_null()
      - col_is_numeric()
      - col_vals_between(1000, 99999)
  IND:
    desc: Binary indicator
    valid:
      - col_is_numeric()
      - col_vals_in_set(c(0,1))
    rename:
      - when: SUM
        then: 'N'
      - when: AVG
        then: P
  AMT:
    desc: Non-negative, summable quantity
    valid:
      - col_is_numeric()
      - col_vals_gte(0)
  VAL:
    desc: Value
    valid:
      - col_is_numeric()
    rename:
      - when: AVG
        then: VALAV
  CAT:
    desc: Category
    valid:
      - col_is_character()
  CD:
    desc: System-generated code
    valid:
      - col_is_character()
  DT:
    desc: Calendar date in YYYY-MM-DD format
    valid:
      - col_is_date()
level2:
  A:
    desc: Type A

        c: Type C

        c: Type D

      d{4}": []
```

In YAML file, specify:

- Stub names
- Human-readable descriptions
- Validation contracts
- Renaming mappings

```r
library(convo)
convo <- read_convo(“my-vocab.yml”)
```

Assess vocabulary quality

one meaning per stub

one stub per meaning

Assess vocabulary quality

one meaning per stub

```r
bad_convo <- list(
  c("IND", "AMT", "CAT"),
  c("DOG", "CAT")
)
pivot_convo(bad_convo)
```

```
#> $CAT
#> [1] 1 2
```

one stub per meaning

Assess vocabulary quality

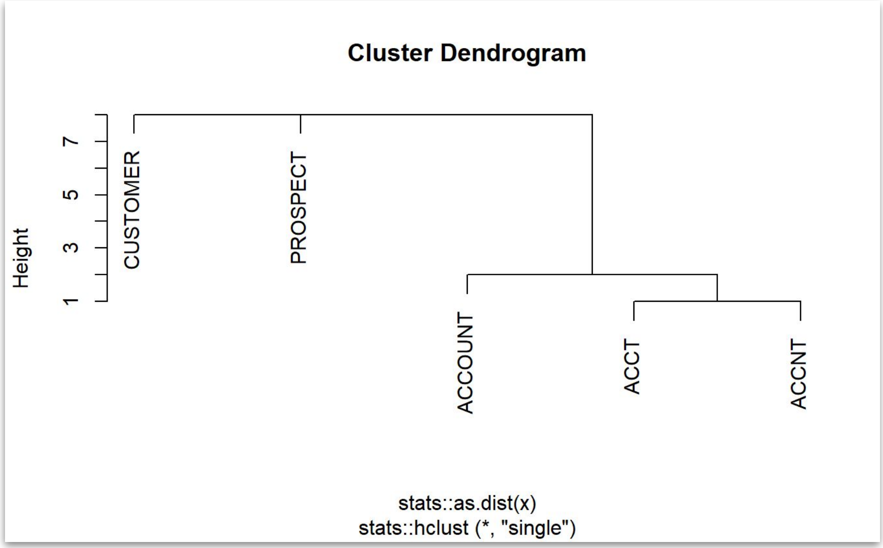
one meaning per stub

```
bad_convo <- list(
  c("IND", "AMT", "CAT"),
  c("DOG", "CAT")
)
pivot_convo(bad_convo)
```

```
#> $CAT
#> [1] 1 2
```

one stub per meaning

```
bad_convo <- list(
  c("IND", "IS", "AMT", "AMOUNT", "CAT", "CD"),
  c("ACCOUNT", "ACCT", "ACCNT", "PROSPECT", "CUSTOMER")
)
clusts <- cluster_convo(bad_convo)
plot(clusts[[2]])
```



Challenge vocabulary realizations

evaluate names

discover new stubs

Challenge vocabulary realizations

evaluate names

discover new stubs

```
col_names <- c(
  "ID_A", "IND_A", "XYZ_D", "AMT_B",
  "AMT_Q", "ID_A_1234", "ID_A_12"
  )
evaluate_convo(convo, col_names, sep = "_")

#> Level 1
#> - XYZ_D
#> Level 2
#> - AMT_B
#> - AMT_Q
#> Level 3
#> - ID_A_12
```

Challenge vocabulary realizations

evaluate names

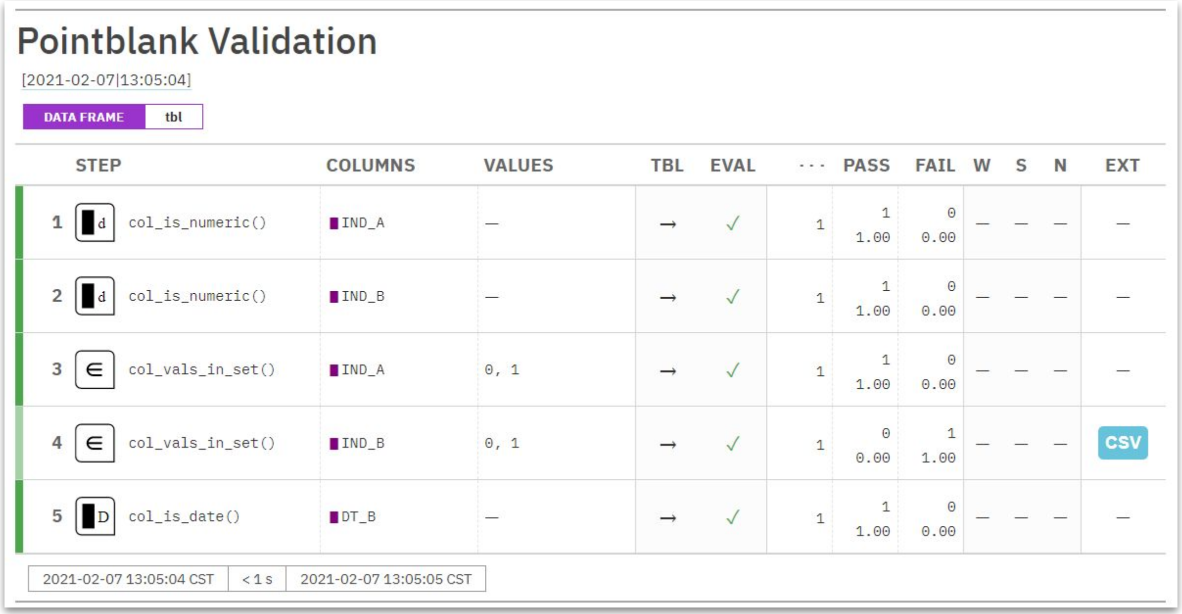
```r
col_names <- c(
  "ID_A", "IND_A", "XYZ_D", "AMT_B",
  "AMT_Q", "ID_A_1234", "ID_A_12"
  )
evaluate_convo(convo, col_names, sep = "_")

#> Level 1
#> - XYZ_D
#> Level 2
#> - AMT_B
#> - AMT_Q
#> Level 3
#> - ID_A_12
```

discover new stubs

```r
convo_colnames <- parse_stubs(col_names)
compare_convo(
  convo_colnames,
  convo,
  fx = "setdiff"
  )

#> Level 1
#> - XYZ
#> Level 2
#> - B
#> - Q
#> Level 3
#> - 12
```

Validate vocabulary promises

```r
data_to_validate <- data.frame(IND_A = 1,
                               IND_B = 5,
                               DT_B = as.Date("2020-01-01"))
agent <- create_pb_agent(convo, data_to_validate)
pointblank::interrogate(agent)
```



Pointblank Validation

[2021-02-07|13:05:04]

DATA FRAME tbl

	STEP	COLUMNS	VALUES	TBL	EVAL	···	PASS	FAIL	W	S	N	EXT
1	d col_is_numeric()	IND_A	—	→	✓	1	1 1.00	0 0.00	—	—	—	—
2	d col_is_numeric()	IND_B	—	→	✓	1	1 1.00	0 0.00	—	—	—	—
3	∈ col_vals_in_set()	IND_A	0, 1	→	✓	1	1 1.00	0 0.00	—	—	—	—
4	∈ col_vals_in_set()	IND_B	0, 1	→	✓	1	0 0.00	1 1.00	—	—	—	CSV
5	D col_is_date()	DT_B	—	→	✓	1	1 1.00	0 0.00	—	—	—	—

2021-02-07 13:05:04 CST | < 1 s | 2021-02-07 13:05:05 CST

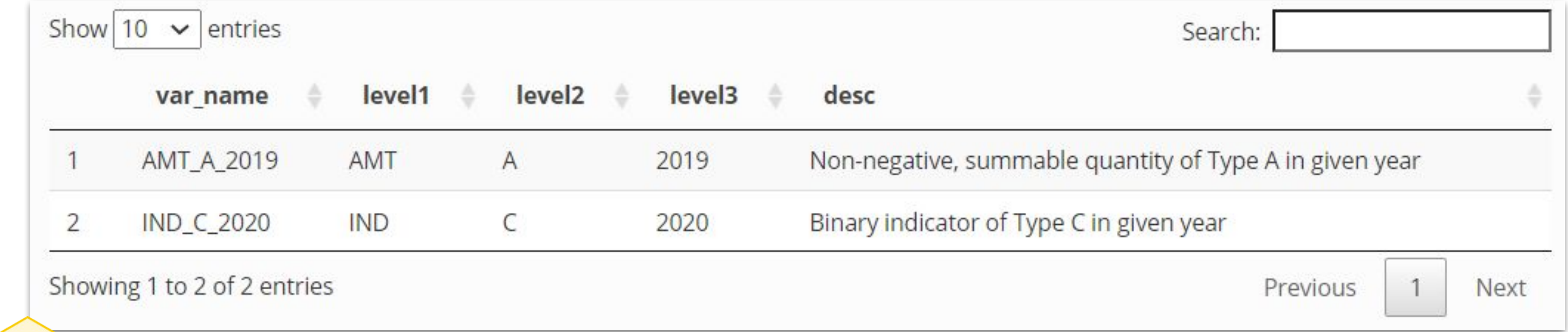
Export validation infrastructure

```
convo <- read_convo(“my-vocab.yml”)
write_pb(convo,
         c("IND_A", "AMT_B"),
         filename = "convo-validation.yml")
```

```
read_fn: ~setNames(as.data.frame(matrix(1,
ncol = 2)), c("IND_A", "AMT_B"))
tbl_name: .na.character
label: '[2021-02-07|13:02:35]'
locale: en
steps:
- col_is_numeric:
    columns: vars(IND_A)
- col_vals_in_set:
    columns: vars(IND_A)
    set:
    - 0.0
    - 1.0
- col_is_numeric:
    columns: vars(AMT_B)
- col_vals_gte:
    columns: vars(AMT_B)
    value: 0.0
```

Generate data documentation

```
vars <- c("AMT_A_2019", "IND_C_2020")
desc_df <- describe_names(
              vars,
              convo,
              desc_str = “{level1} of {level2} in given year”)
DT::datatable(desc_df, escape = FALSE)
```

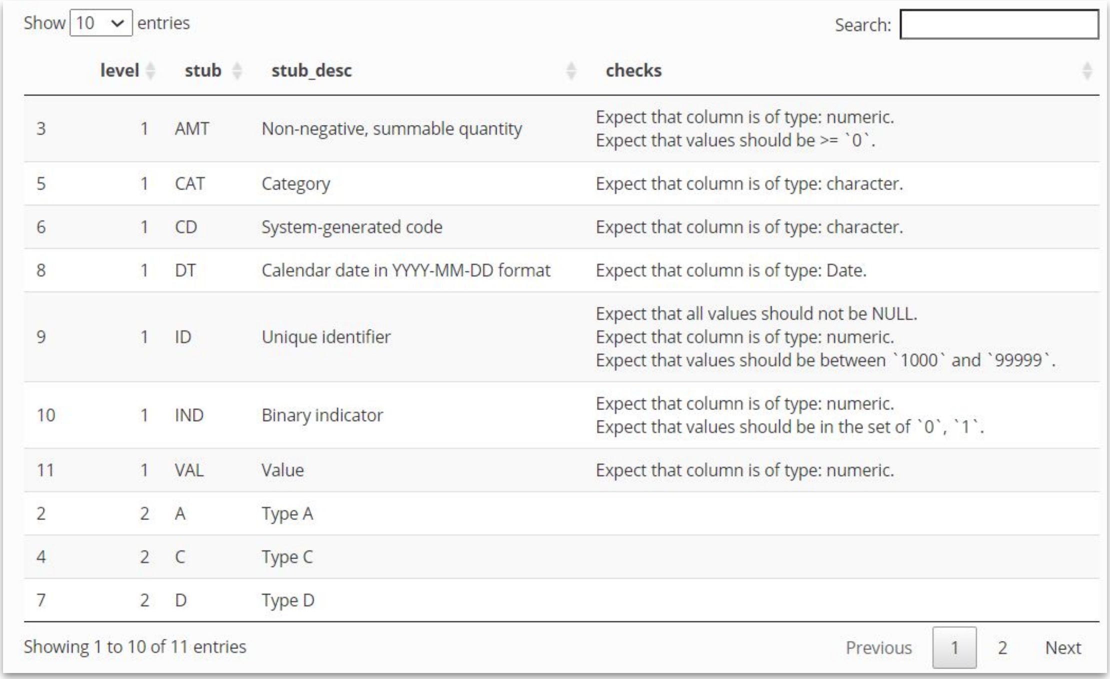


	var_name	level1	level2	level3	desc
1	AMT_A_2019	AMT	A	2019	Non-negative, summable quantity of Type A in given year
2	IND_C_2020	IND	C	2020	Binary indicator of Type C in given year

Showing 1 to 2 of 2 entries

Generate dictionary documentation

```r
desc_df <- describe_convo(convo,
                          include_valid = TRUE,
                          for_DT = TRUE)
DT::datatable(desc_df, escape = FALSE)
```



	level	stub	stub_desc	checks
3	1	AMT	Non-negative, summable quantity	Expect that column is of type: numeric. Expect that values should be >= `0`.
5	1	CAT	Category	Expect that column is of type: character.
6	1	CD	System-generated code	Expect that column is of type: character.
8	1	DT	Calendar date in YYYY-MM-DD format	Expect that column is of type: Date.
9	1	ID	Unique identifier	Expect that all values should not be NULL. Expect that column is of type: numeric. Expect that values should be between `1000` and `99999`.
10	1	IND	Binary indicator	Expect that column is of type: numeric. Expect that values should be in the set of `0`, `1`.
11	1	VAL	Value	Expect that column is of type: numeric.
2	2	A	Type A	
4	2	C	Type C	
7	2	D	Type D	

Showing 1 to 10 of 11 entries

SQL templating standardizes metric definition and naming

```
select

  id_county,
  dt_county,

  {% for l in var('lags') %}

    lag(cases, {{l}})
        over (partition by id_county
              order by dt_county)
        as n_case_pred_{{l}}

  {% if not loop.last %},{% endif %}
  {% endfor %}

 from predictions_source_table
```

```
select

  id_county,
  dt_county,

  lag(cases, 07)
      over (partition by id_county
            order by dt_county)
      as n_case_pred_07,

  lag(cases, 14)
      over (partition by id_county
            order by dt_county)
      as n_cases_pred_14,

  lag(cases, 21)
      over (partition by id_county
            order by dt_county)
      as n_cases_pred_21,

  lag(cases, 24)
      over (partition by id_county
            order by dt_county)
      as n_cases_pred_24,

...
```

Custom macros enable programmatic wrangling of data to enforce contracts

```
{% set cols = get_column_names( ref(‘data’) ) %}
{% set cols_n = starts_with(cols, ‘n’) %}
{% set cols_dt = starts_with(cols, ‘dt’) %}
{% set cols_ind = starts_with(cols, ‘ind’) %}
{% set cols_oth =
         not_one_of(cols,
               cols_n + cols_dt + cols_ind %}

select

  {{ across(cols_oth, “{var}”) }},
  {{ across(cols_n, “cast({var} as int)”)}},
  {{ across(cols_dt, “date({var}) as {var})”)}},
  {{ across(cols_ind, “coalesce({c}, 0)”) }}

 from {{ ref('data') }}
```

```
select

  amt_a,
  amt_b,

  cast(n_a as int64) as n_a,
  cast(n_c as int64) as n_c,

  date(dt_b) as dt_b,
  date(dt_d) as dt_d,

  coalesce(ind_b,0) as ind_b,
  coalesce(ind_c,0) as ind_c

from db.schema.data
```

Testing confirms any non-enforceable contracts are upheld

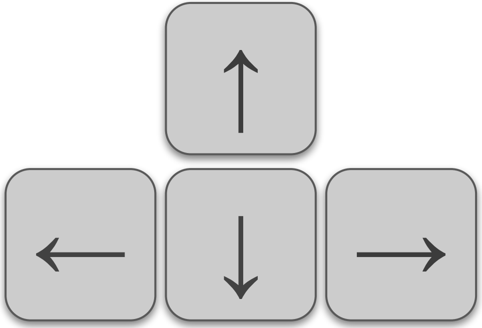
```
{% set cols = get_column_names(ref('prep')) %}
{% set cols_n = starts_with(cols, 'n') %}

select *
from {{ ref('model_monitor_staging') }}
where
 {%- for c in cols_n %}
  abs({{c}} - cast({{c}} as int64)) > 0.01 or
 {% endfor %}
  FALSE
```

```
with dbt__CTE__INTERNAL_test as (

select *
from `sonorous-wharf-302611`.`dbt_emily`.`model_monitor_staging`
where

    abs(n_case_actl - cast(n_case_actl as int64)) > 0.01 or
    abs(n_death_actl - cast(n_death_actl as int64)) > 0.01 or
    abs(n_case_pred_07 - cast(n_case_pred_07 as int64)) > 0.01 or
    abs(n_hosp_pred_07 - cast(n_hosp_pred_07 as int64)) > 0.01 or
    abs(n_death_pred_07 - cast(n_death_pred_07 as int64)) > 0.01 or
    abs(n_case_pred_14 - cast(n_case_pred_14 as int64)) > 0.01 or
    abs(n_hosp_pred_14 - cast(n_hosp_pred_14 as int64)) > 0.01 or
    abs(n_death_pred_14 - cast(n_death_pred_14 as int64)) > 0.01 or
    abs(n_case_pred_21 - cast(n_case_pred_21 as int64)) > 0.01 or
    abs(n_hosp_pred_21 - cast(n_hosp_pred_21 as int64)) > 0.01 or
    abs(n_death_pred_21 - cast(n_death_pred_21 as int64)) > 0.01 or
    abs(n_case_pred_28 - cast(n_case_pred_28 as int64)) > 0.01 or
    abs(n_hosp_pred_28 - cast(n_hosp_pred_28 as int64)) > 0.01 or
    abs(n_death_pred_28 - cast(n_death_pred_28 as int64)) > 0.01 or

   FALSE
)

select count(*) from dbt__CTE__INTERNAL_test
```

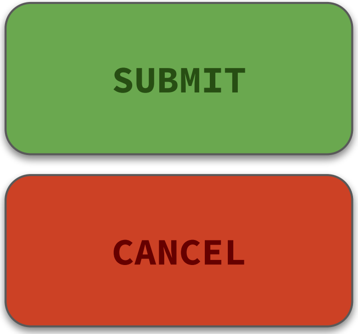
Column names can make performance contracts

Universal Symbols

Grouping



Aesthetics



Thank you!

More thoughts on my website:

- Under the `data` tag: emily.rbind.io/tags/data/
- Column Names as Contracts
- Introducing {convo} + open design questions!
- Embedding column-name contracts in dbt pipelines
- {convo} package website
- dbt-dplyr GitHub repo