Chi-square
+ practice

18

Probability and Statistics

COMS10011
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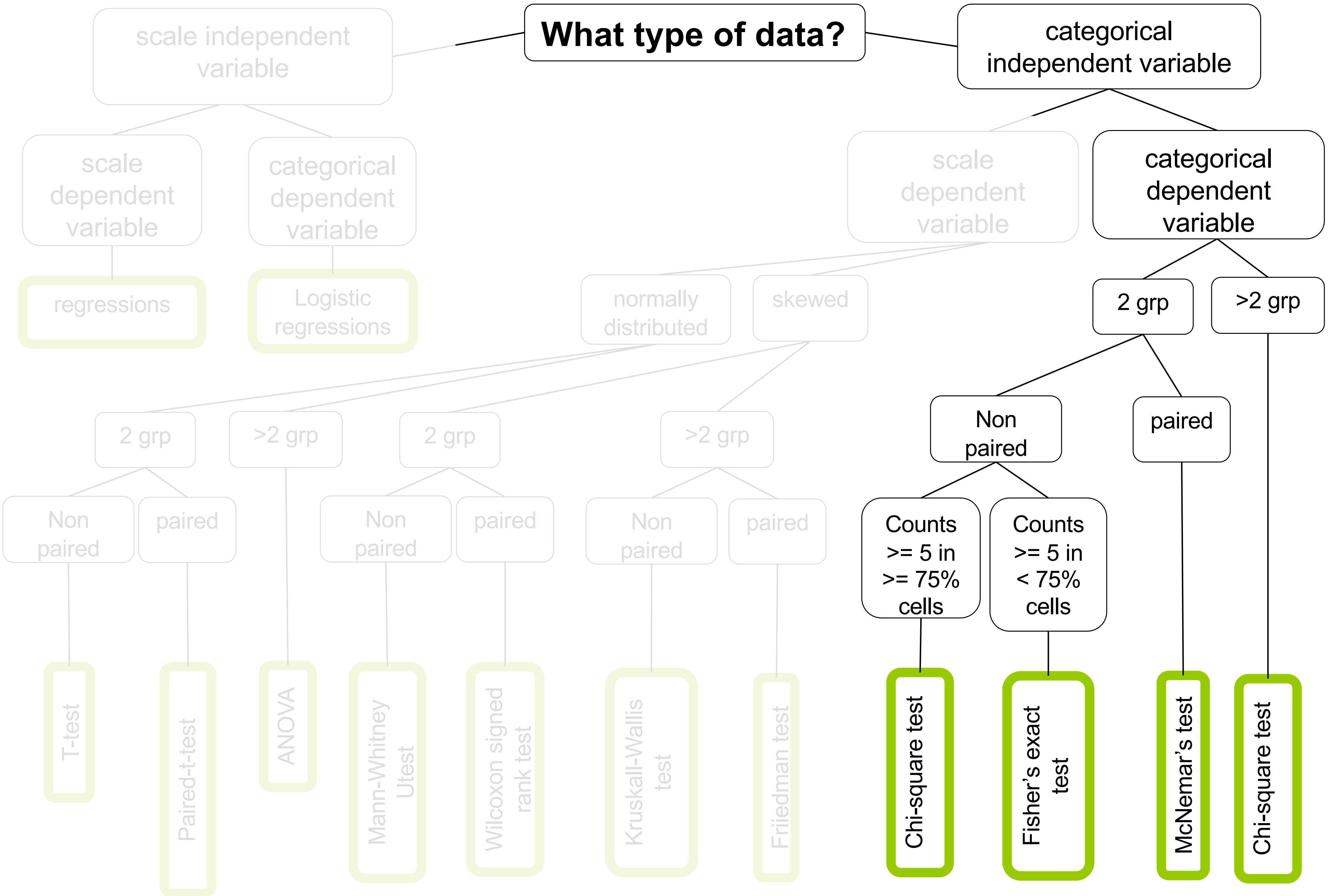
What type of data?
scale independent variable
categorical independent variable
scale dependent variable
categorical dependent variable
regressions
Logistic regressions
scale dependent variable
categorical dependent variable
normally distributed
skewed
2 grp
>2 grp
2 grp
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2 grp
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Non paired
paired
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Counts >= 5 in >= 75% cells
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Friedman test
Chi-square test
Fisher's exact test
McNemar's test
Chi-square test

until now, we did statistical test using means or medians but the assumptions for means have eliminated certain types of variables (e.g. gender)

mean not appropriate measure of central tendency for nominal (categorical type) data

Chi-square can do do!

there are two types of Chi-square tests:

goodness of fit test (for one variable only)
contingency table test (for two variables at a time)

goodness of fit

looks to **see if a single variable fits some hypothesised probability distribution**

e.g. in a population of students, there would be an equal number of students who like or dislike brussels sprouts

in fact we don’t even have to go 50/50, we may theorize that only 1/4 (25%) will like them (because they are disgusting!)

	# of persons
like BP	11
Dislike BP	139
	150 (total)

	# of persons	%expected	# expected
like BP	11	25%	37.5 (25% of 150)
Dislike BP	139	75%	112.5 (75% of 150)
	150 (total)	100%	150 (total)

observed cases

expected cases

$$X^2 = \sum \frac{(o-e)^2}{e}$$

$$= \frac{(11-37.5)^2}{37.5} + \frac{(139-112.5)^2}{112.5}$$

$$= 24.96$$

now, like with all the test we have seen, we look into a table, here the Chi-square table)

Critical values of the Chi-square distribution with *d* degrees of freedom

	Probability of exceeding the critical value						
d	0.05	0.01	0.001	*d*	0.05	0.01	0.001
1	$\boxed{3.841}$	6.635	10.828	11	19.675	24.725	31.264
2	5.991	9.210	13.816	12	21.026	26.217	32.910
3	7.815	11.345	16.266	13	22.362	27.688	34.528
4	9.488	13.277	18.467	14	23.685	29.141	36.123
5	11.070	15.086	20.515	15	24.996	30.578	37.697
6	12.592	16.812	22.458	16	26.296	32.000	39.252
7	14.067	18.475	24.322	17	27.587	33.409	40.790
8	15.507	20.090	26.125	18	28.869	34.805	42.312
9	16.919	21.666	27.877	19	30.144	36.191	43.820
10	18.307	23.209	29.588	20	31.410	37.566	45.315

degree of freedom DF
= number of group - 1

24.96 > 3.841 so we **reject the null hypothesis**

our theory of 25% Brussel Sprout lovers does not hold

	# of persons	%expected	# expected
like BP	25	25%	25 (25% of 100)
Dislike BP	75	75%	75 (75% of 100)
	100 (total)	100%	100 (total)

observed cases

expected cases

$$X^2 = \sum \frac{(o-e)^2}{e}$$

$$= \frac{(25-25)^2}{25} + \frac{(75-75)^2}{75} = 0$$

if data was perfect fit (pvalue would be = 1)

… cannot reject null (thus cannot conclude) let's see if our theory holds with a raise of hand

who like Brussel sprout?

who dislike Brussel sprout?

```
table = c(11,139)
chisq.test(tulip, p = c(1/4, 3/4))

Chi-squared test for given probabilities


data:  table
X-squared = 24.969, df = 1, p-value = 5.826e-07
```

this example is fairly simple but Chi-square also work with more data, e.g. 30% prefer eating chicken for Christmas dinner, 50% prefer turkey, 10% prefer vegetarian option, 10% prefer other types of meat

contingency tables

public opinion surveys tend to show there is a relationship between gender and *something*, e.g. preference in sport car vs. family car (public opinion surveys are very stereotypical!)

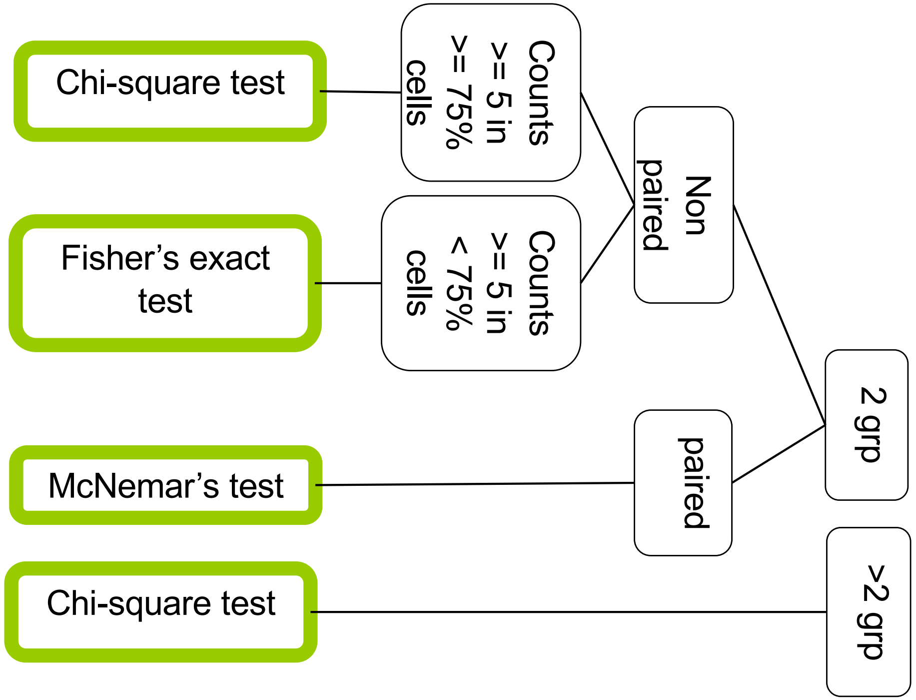
so here we have **two variables/groups**: gender (female or male) and car preference (sport or family)

	male	female
sport	26	3
family	24	22

we do a **Chi-square contingency table test** to prove preference of car is related to or dependant upon gender

```
table = matrix(c(26, 24, 3, 22), ncol=2)
colnames(table) = c('male', 'female')
rownames(table) = c('sport','family’)
addmargins(table)

       male female Sum
sport    26      3  29
family   24     22  46
Sum      50     25  75

chisq.test(table,correct=FALSE) #must use correct=FALSE
for a 2 by 2 table otherwise = TRUE


Pearson's Chi-squared test


data:  table
X-squared = 11.244, df = 1, p-value = 0.0007986
```

we reject the null and conclude that car type preference is dependant of gender extra R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Chi-square test

Fisher

```
> library(MASS)        # load the MASS package
> tbl = table(survey$Smoke, survey$Exer)
> tbl                  # the contingency table

        Freq None Some
  Heavy    7    1    3
  Never   87   18   84
  Occas   12    3    4
  Regul    9    1    7

fisher.test(tbl) # if Counts >= 5 in < 75% cells otherwise
or chisq.test(tbl)


        Fisher's Exact Test for Count Data


data:  tbl
p-value = 0.4138
alternative hypothesis: two.sided
```

mcnemar

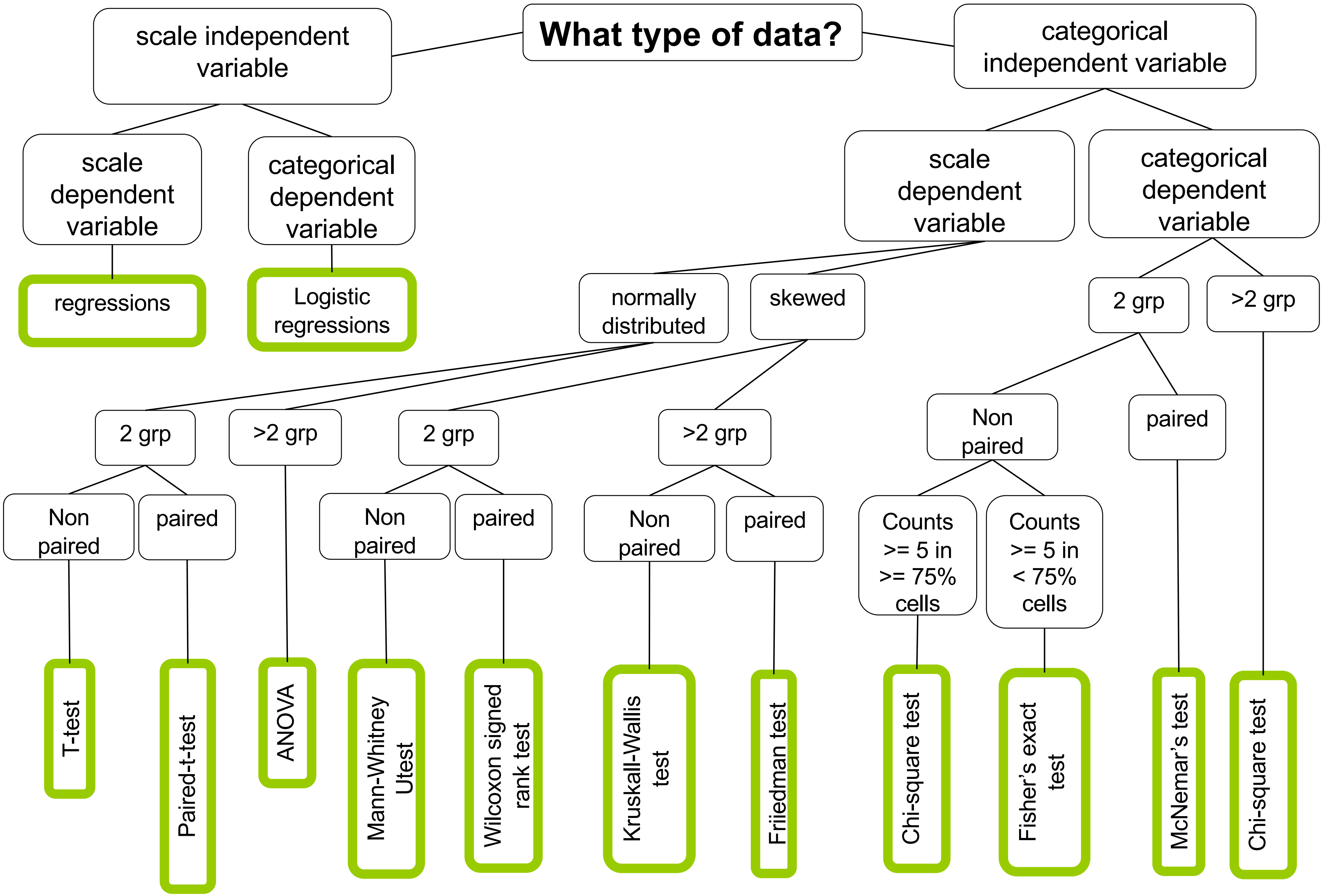
```
# mcnemar example on presidential Approval Ratings:
Approval of the President's performance in office in two
surveys, one month apart, for a random sample of 1600
voting-age Americans.

Performance <- matrix(c(794, 86, 150, 570), nrow = 2,
dimnames = list("1st Survey" = c("Approve", "Disapprove"),
"2nd Survey" = c("Approve", "Disapprove")))
Performance
```

```
            2nd Survey
1st Survey    Approve Disapprove
  Approve         794        150
  Disapprove       86        570
```

```
mcnemar.test(Performance)
```

pre-summary

ok so now you know almost all the tests needed!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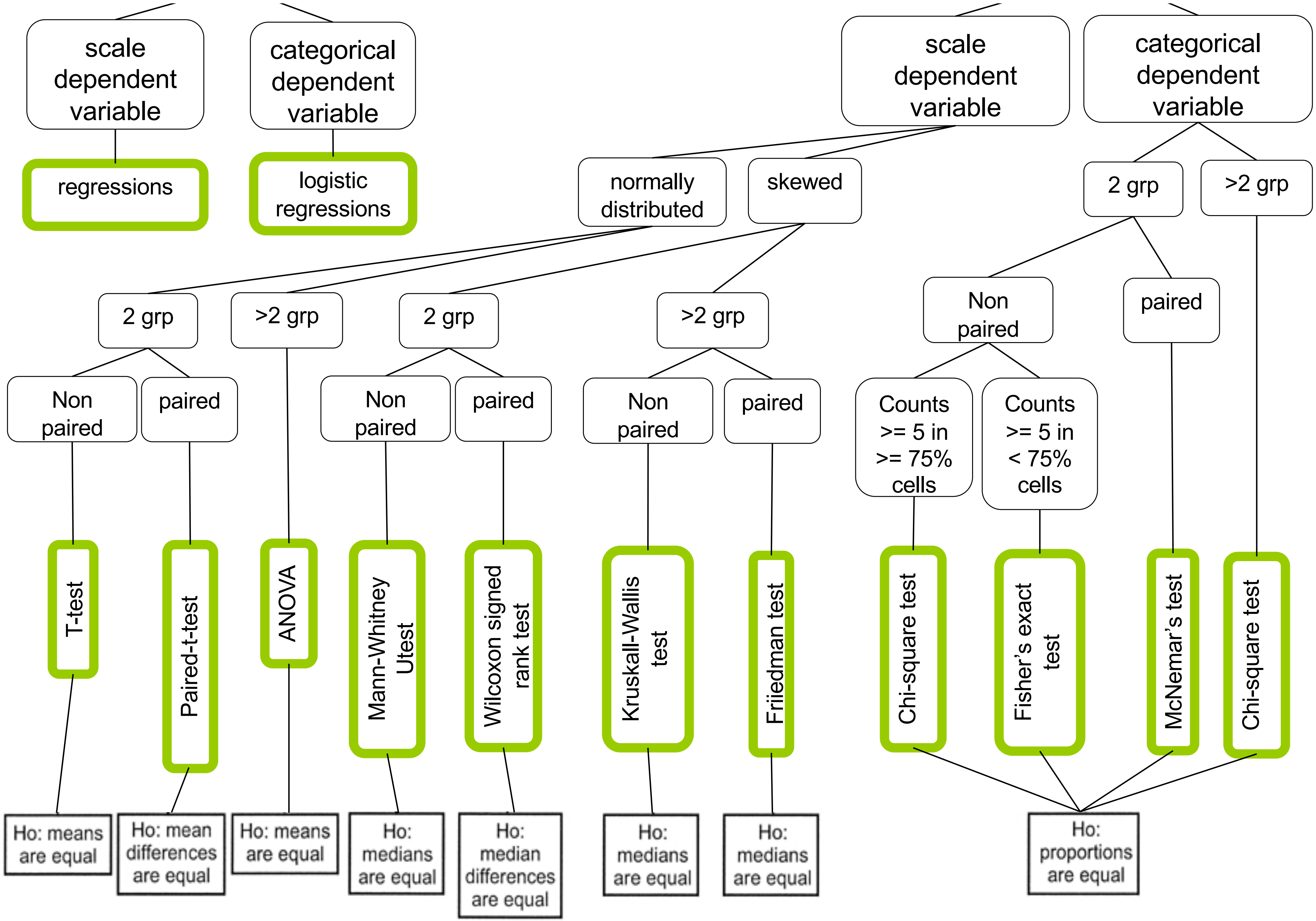

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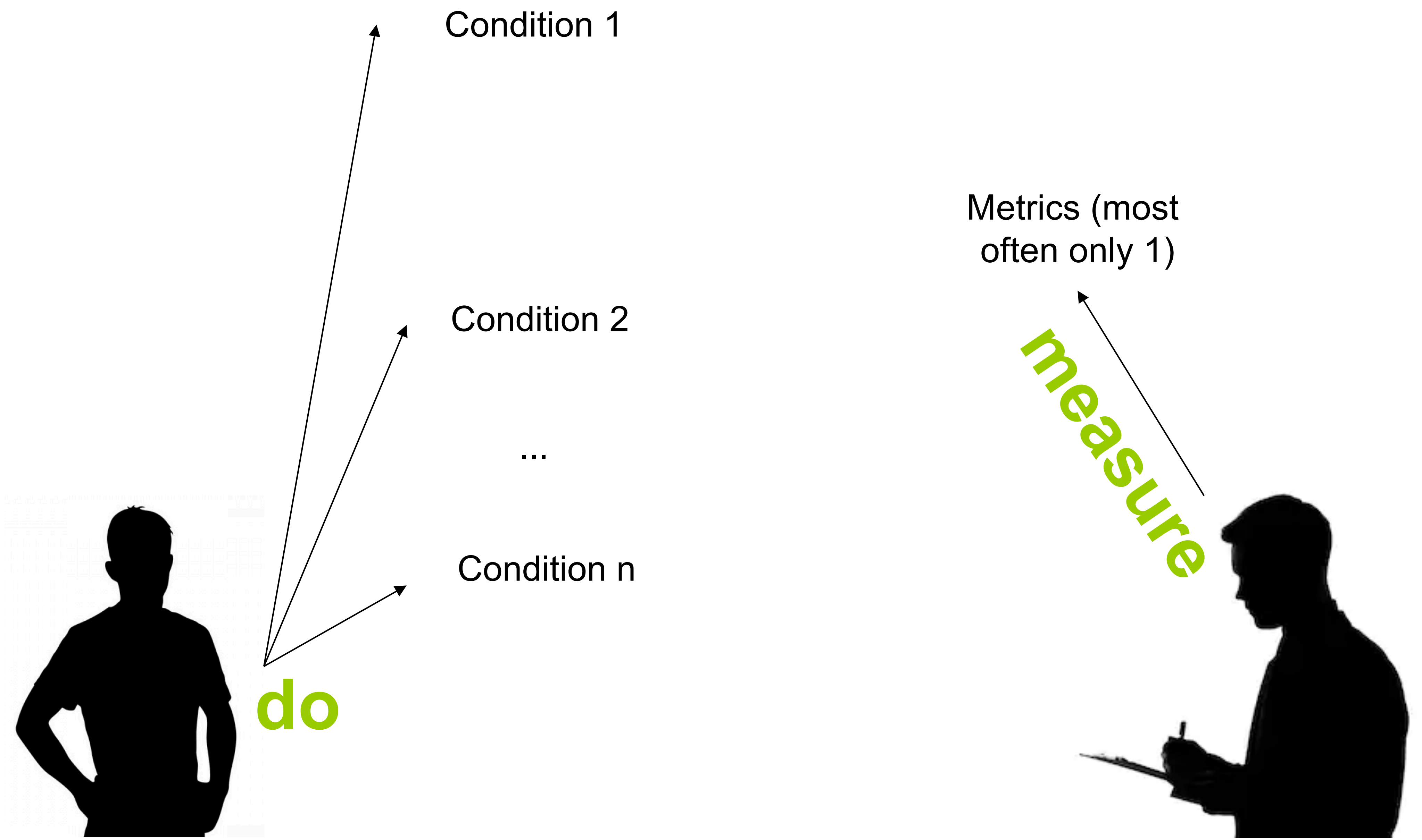
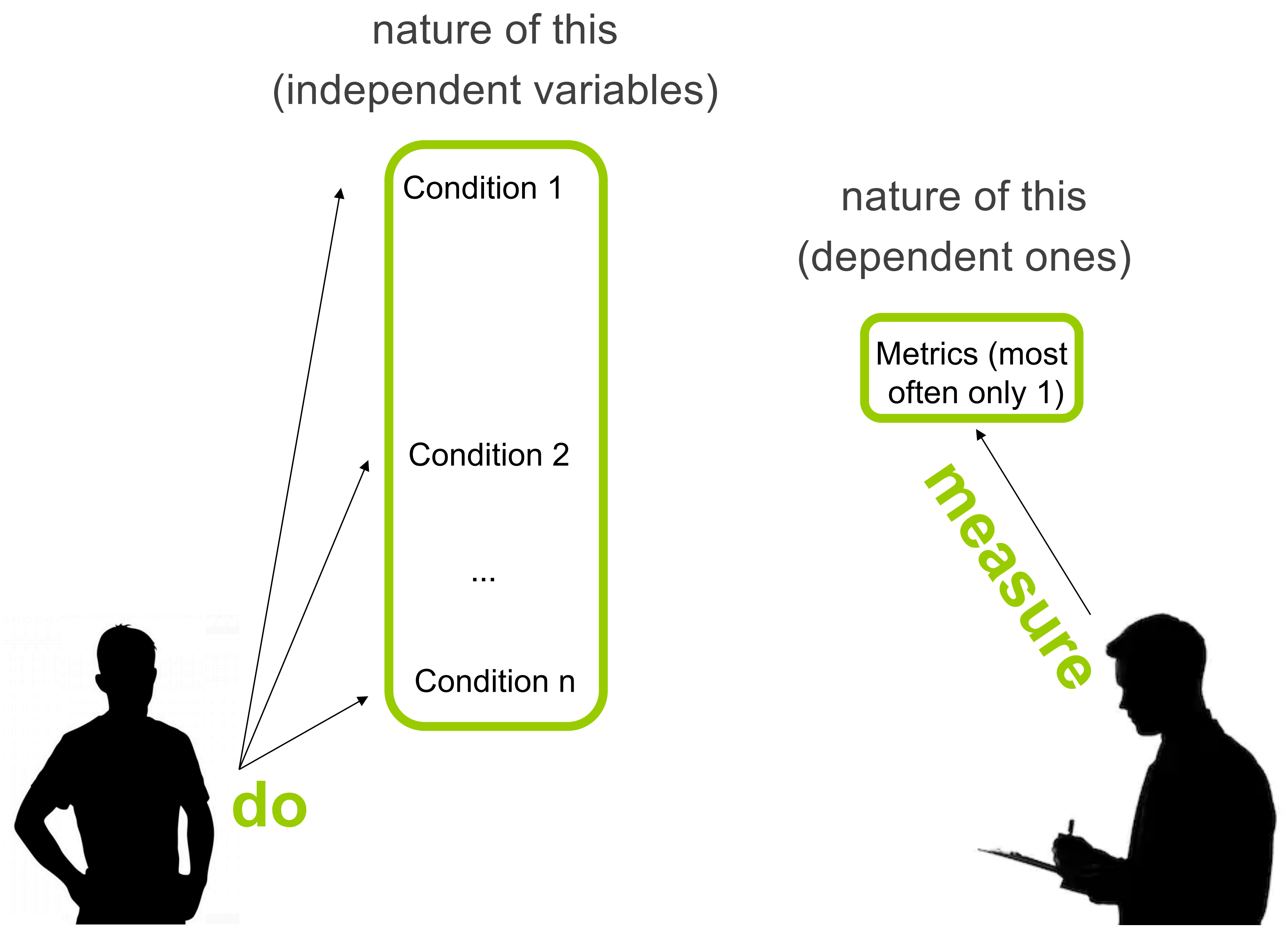
Ho: means are equal
Ho: mean differences are equal
Ho: means are equal
Ho: medians are equal
Ho: median differences are equal
Ho: medians are equal
Ho: medians are equal
Ho: proportions are equal

the most important is not that you do these by hands but that you understand the intuition behind them and more importantly **when to use them**

practice


Condition 1
Condition 2
...
Condition n
do
Metrics (most often only 1)
measure


nature of this
(independent variables)
Condition 1
Condition 2
...
Condition n
do
nature of this
(dependent ones)
Metrics (most often only 1)
measure

scale independent variable

What type of data?

categorical independent variable

Condition 1

Condition 2

...

Condition n

Continuous IV?

Size of targets users point at

Weight of users

Amount of chocolate eaten

Or discrete IV?

Chocolate vs. not vs. punishment

Gender

Milk before or after

do

scale independent variable

What type of data?

caterorical independent variable

Condition 1

Condition 2

...

Condition n

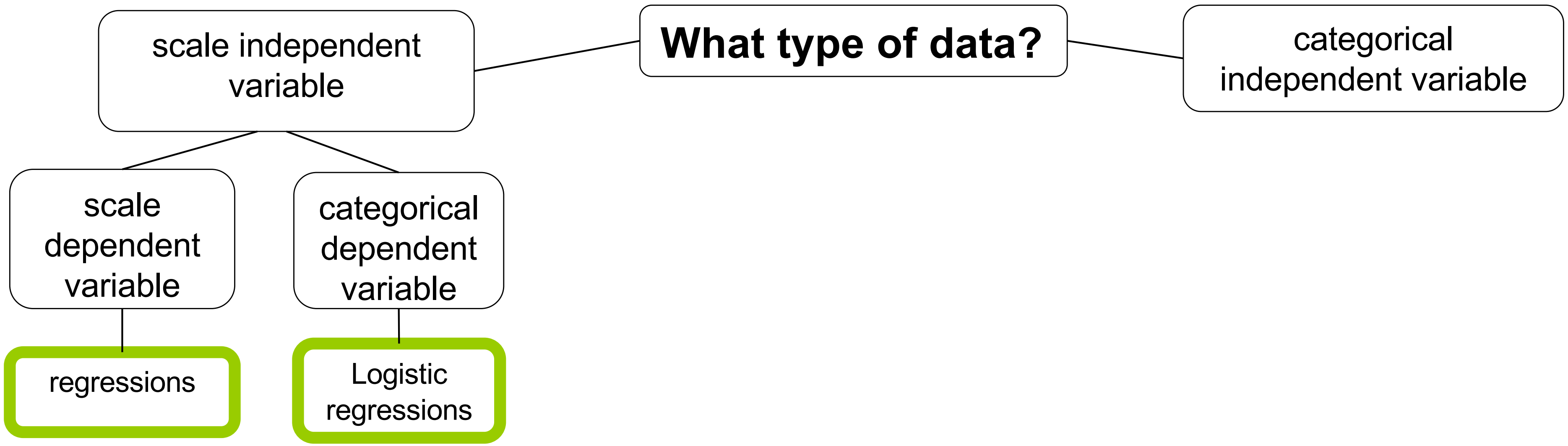
Continuous IV?

- Size of targets users point at
- Weight of users
- Amount of chocolate eaten

Or discrete IV?

- Chocolate vs. not vs. punishment
- Gender
- Milk before or after

do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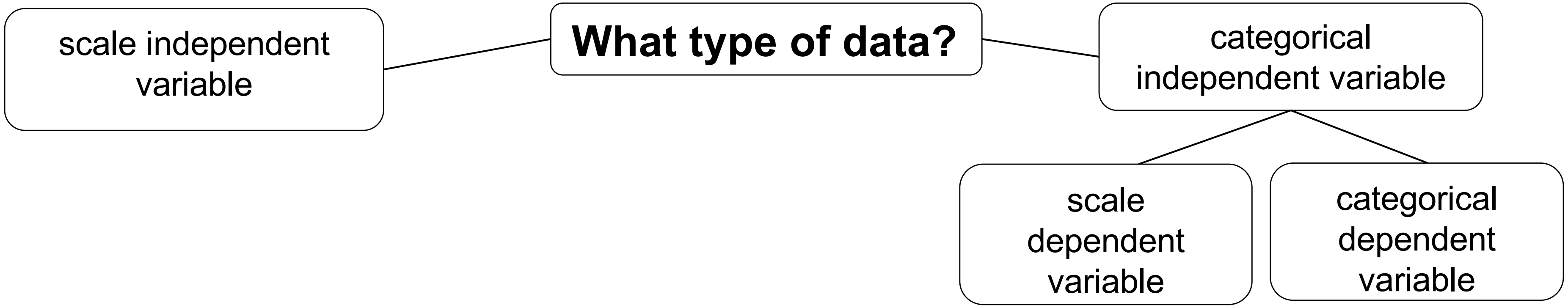
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Metrics (most often only 1)

measure

What type of data?

scale independent variable

categorical independent variable

scale dependent variable

categorical dependent variable

Continuous DV?

Memorization score

Time or errors

Liker scale answers (special case!)

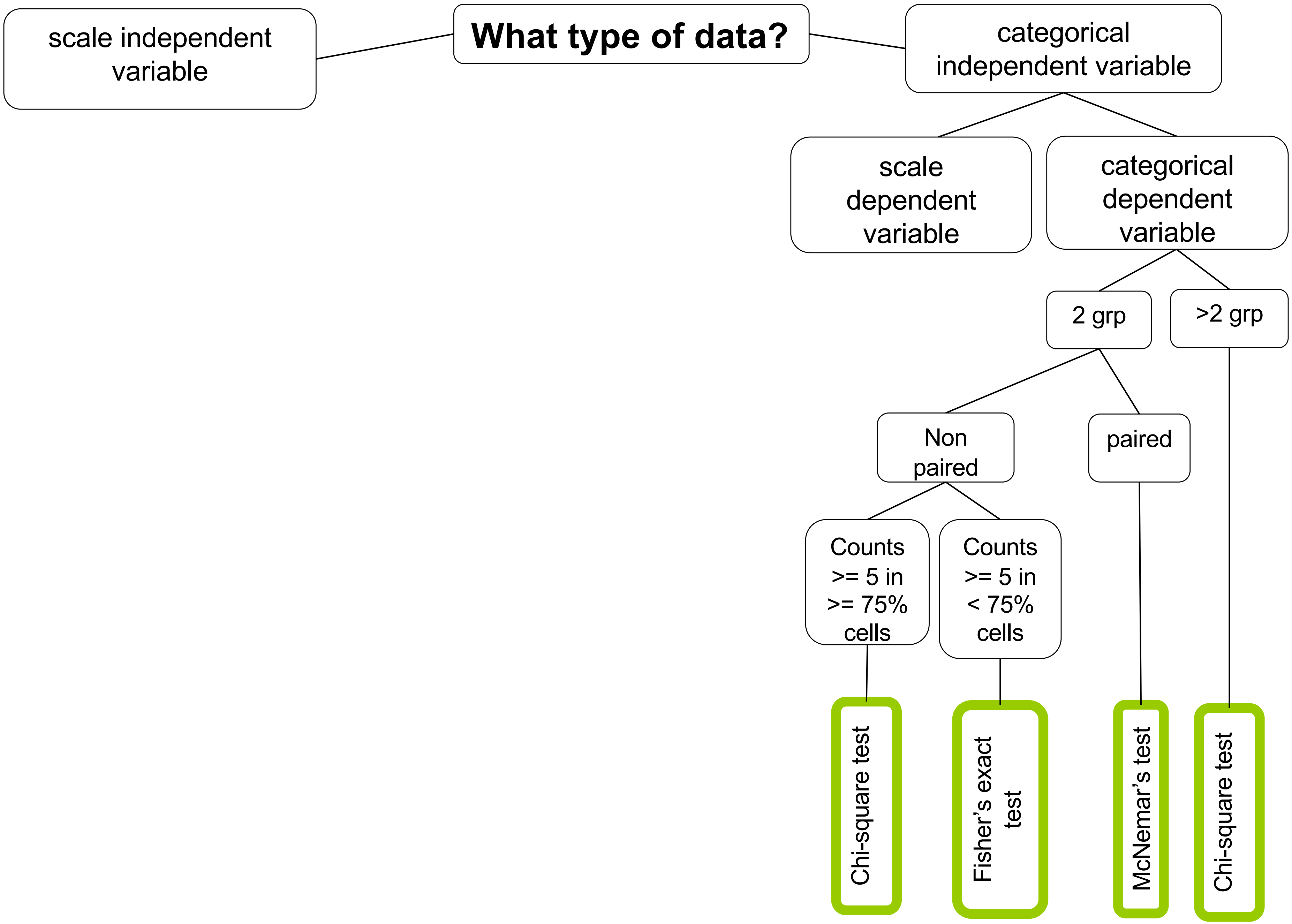
Metrics (most often only 1)

Or discrete DV?

Yes No answer

Preference between X categories

Gender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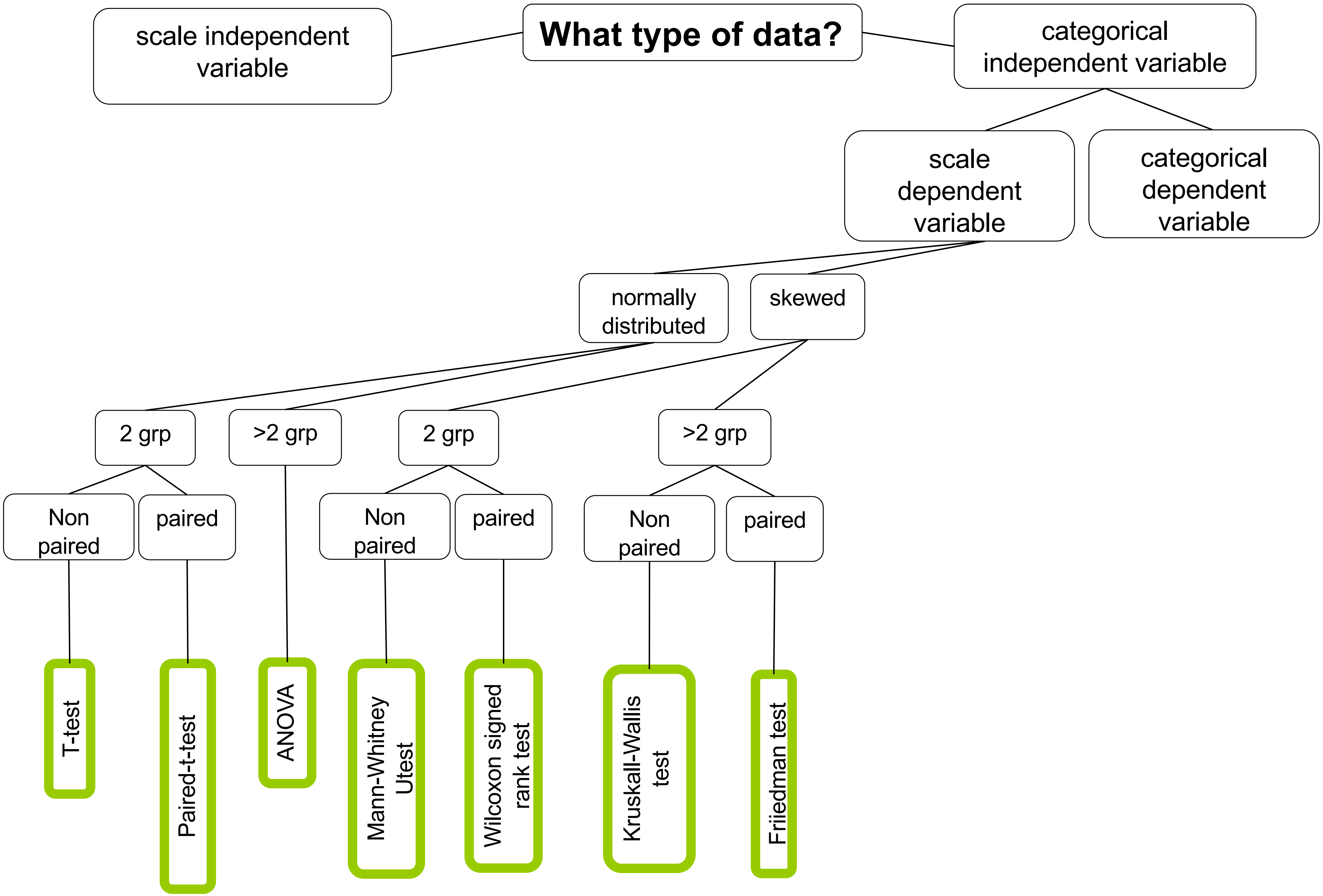
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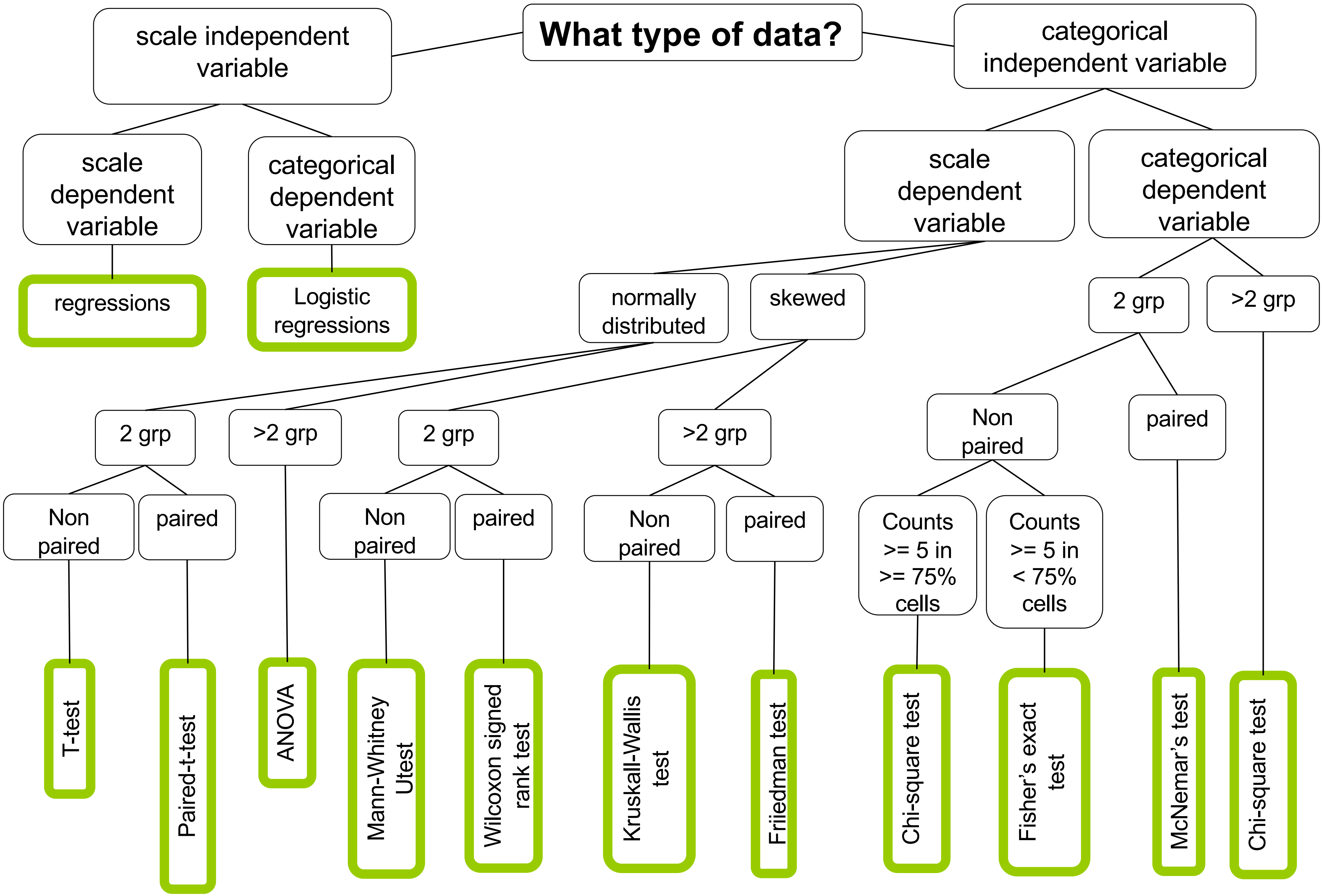
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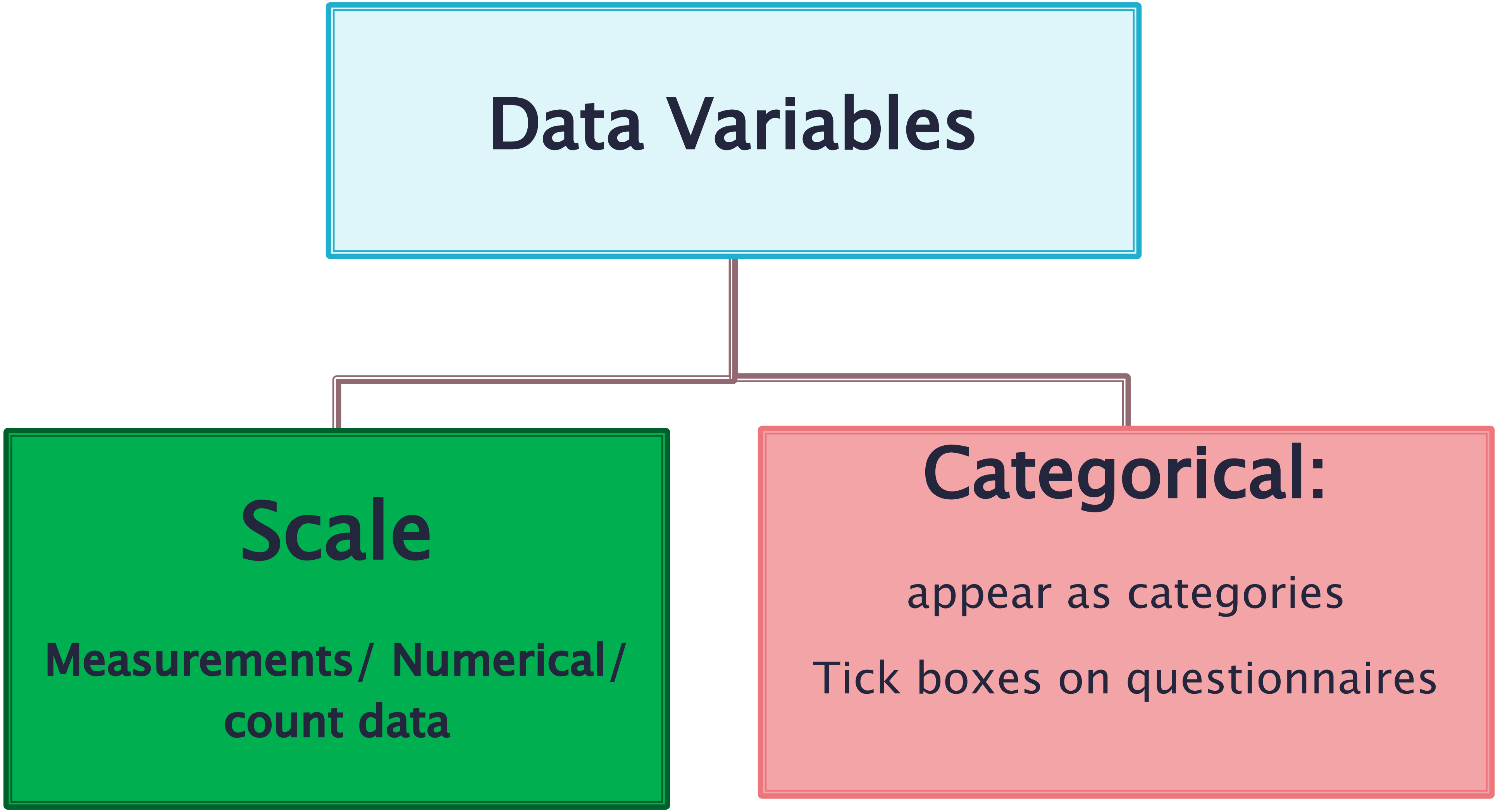
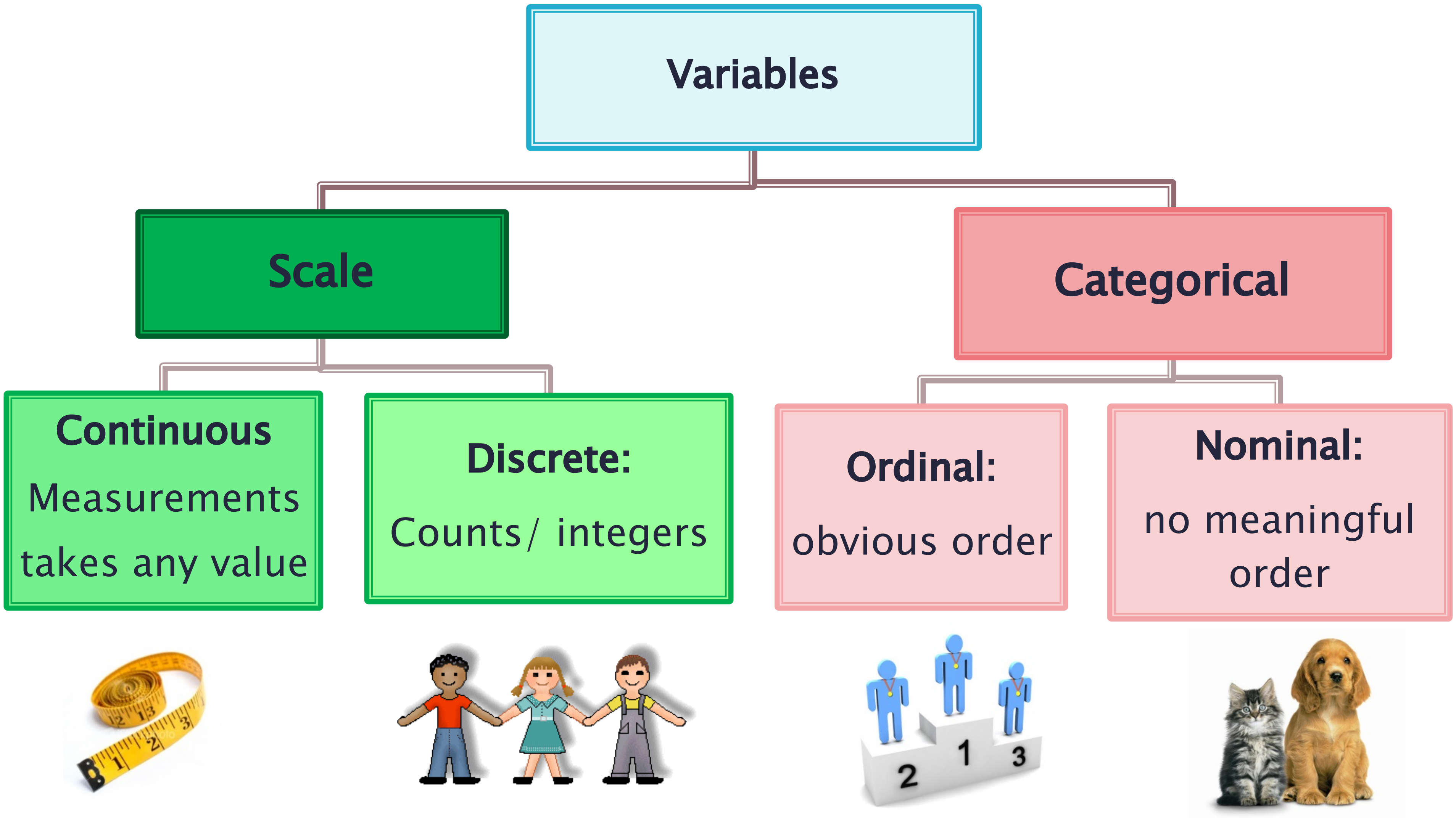
recognising data types



Data Variables
Scale
Measurements/ Numerical/ count data
Categorical:
appear as categories
Tick boxes on questionnaires


Variables
Scale
Categorical
Continuous
Measurements
takes any value
Discrete:
Counts/ integers
Ordinal:
obvious order
Nominal:
no meaningful order
1
2
3

Q1: What is your favourite subject?

Maths	English	Science	Art	French

Q2: Gender:

Male	Female

Q3: I consider myself to be good at mathematics:

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

Q4: Score in a recent mock GCSE maths exam:

Score between 0% and 100%

Q1: What is your favourite subject? **Categorical / Nominal**

Maths	English	Science	Art	French

Q2: Gender:

Male	Female

Categorical / Nominal (binary)

Q3: I consider myself to be good at mathematics:

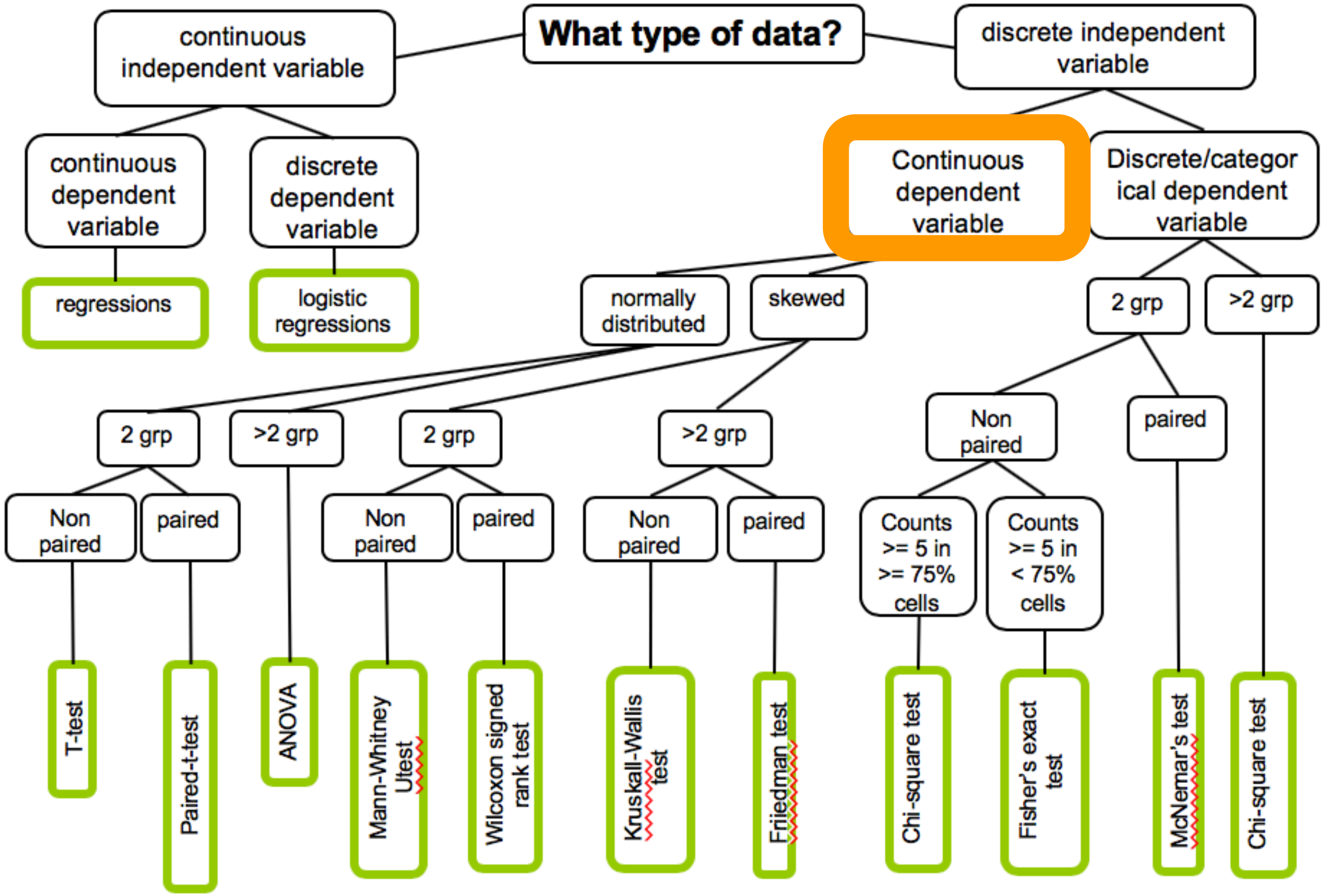
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree

Categorical / Ordinal

Q4: Score in a recent mock GCSE maths exam:

Score between 0% and 100%

Scale



Likert can be treated as **continuous**

summary

1. Be able to give the CHI-square formula (goodness of fit and contingency table)
2. Calculate a CHI-square by hand on an example with a single variable and conclude
3. Explain what is the different between goodness of fit and contingency table methods

4. Be able to navigate the mother of all stats graph! = know how to identify a variable type and choose appropriate test

take away

in the exam the only calculations I could make you do are linear regression or chi square

you don't need to learn the formula for all the other statistic tests

take away

1. Linear regression
2. Hypothesis testing, comparing things
3. Experimental design part 1
4. Experimental design part 2
5. T-test and ANOVA
6. Pre-requisite to ANOVA
7. Non-parametric tests
8. Categorical data: Chi-square
9. **Sample size, power and effect size (guest)**
10. **P-hacking and alternatives tests (guest)**

unit menu

end