Meaningful and reproducible statistics:

Does my data hold what it promises?

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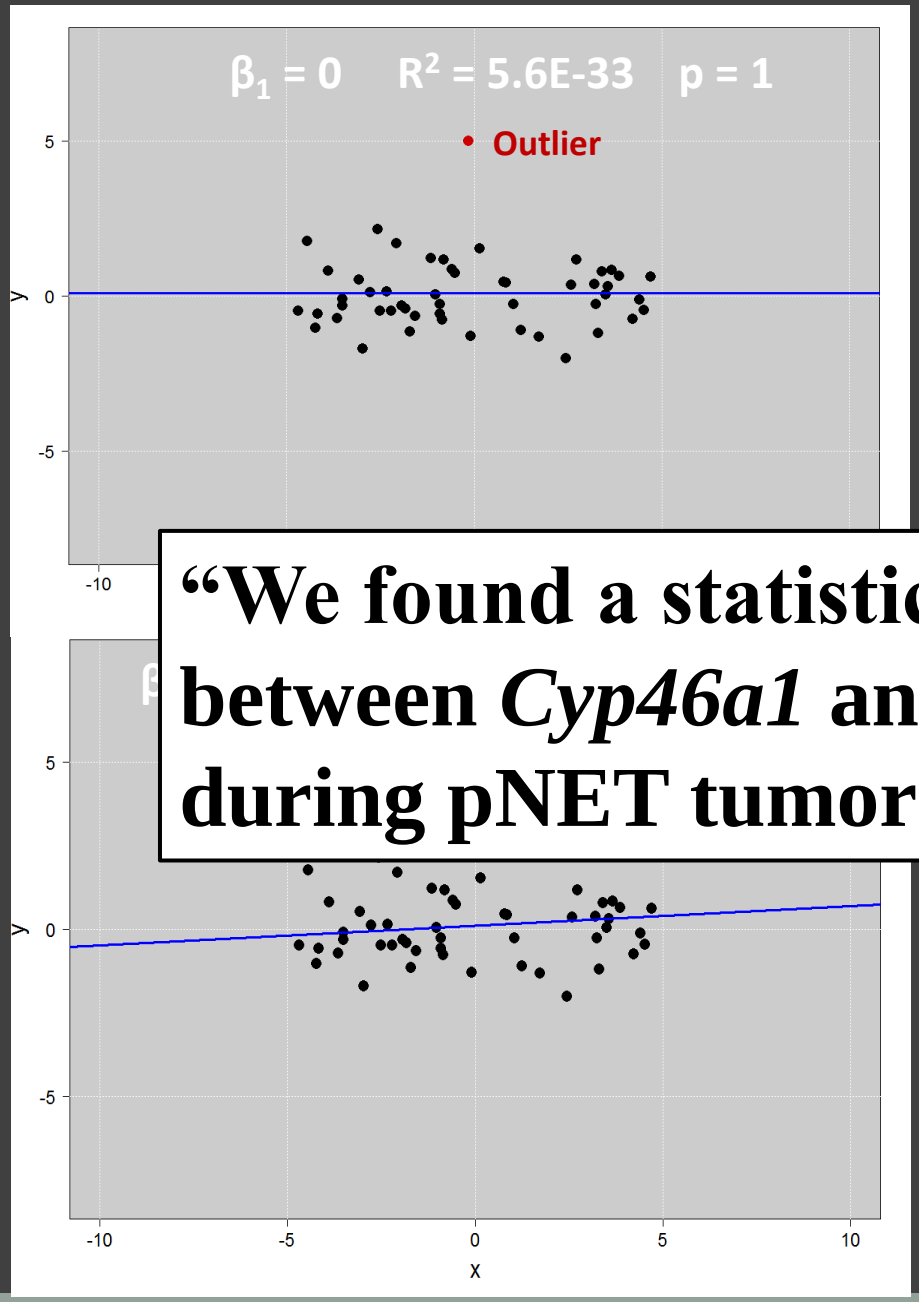
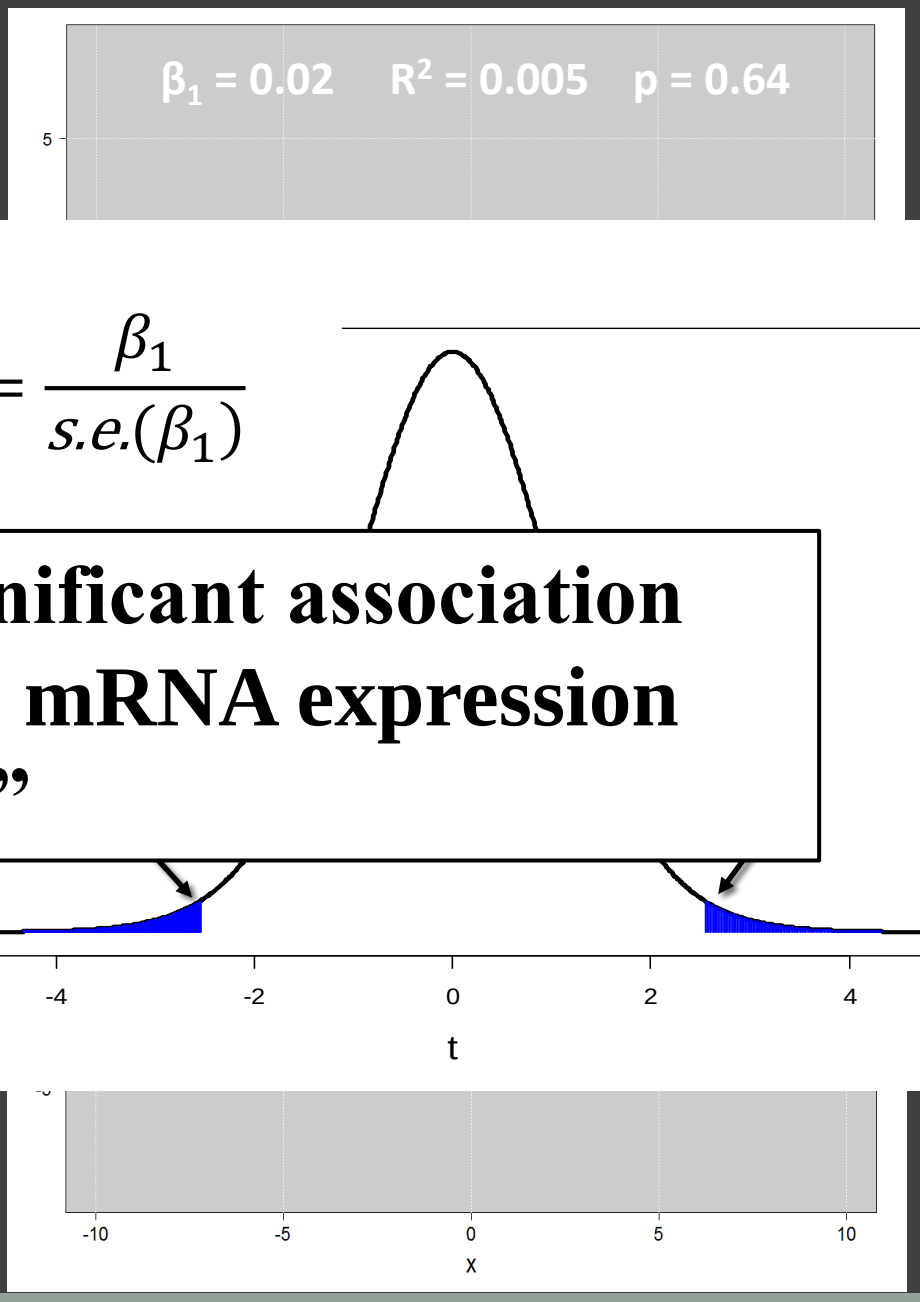




$$t = \frac{\beta_1}{s.e.(\beta_1)}$$

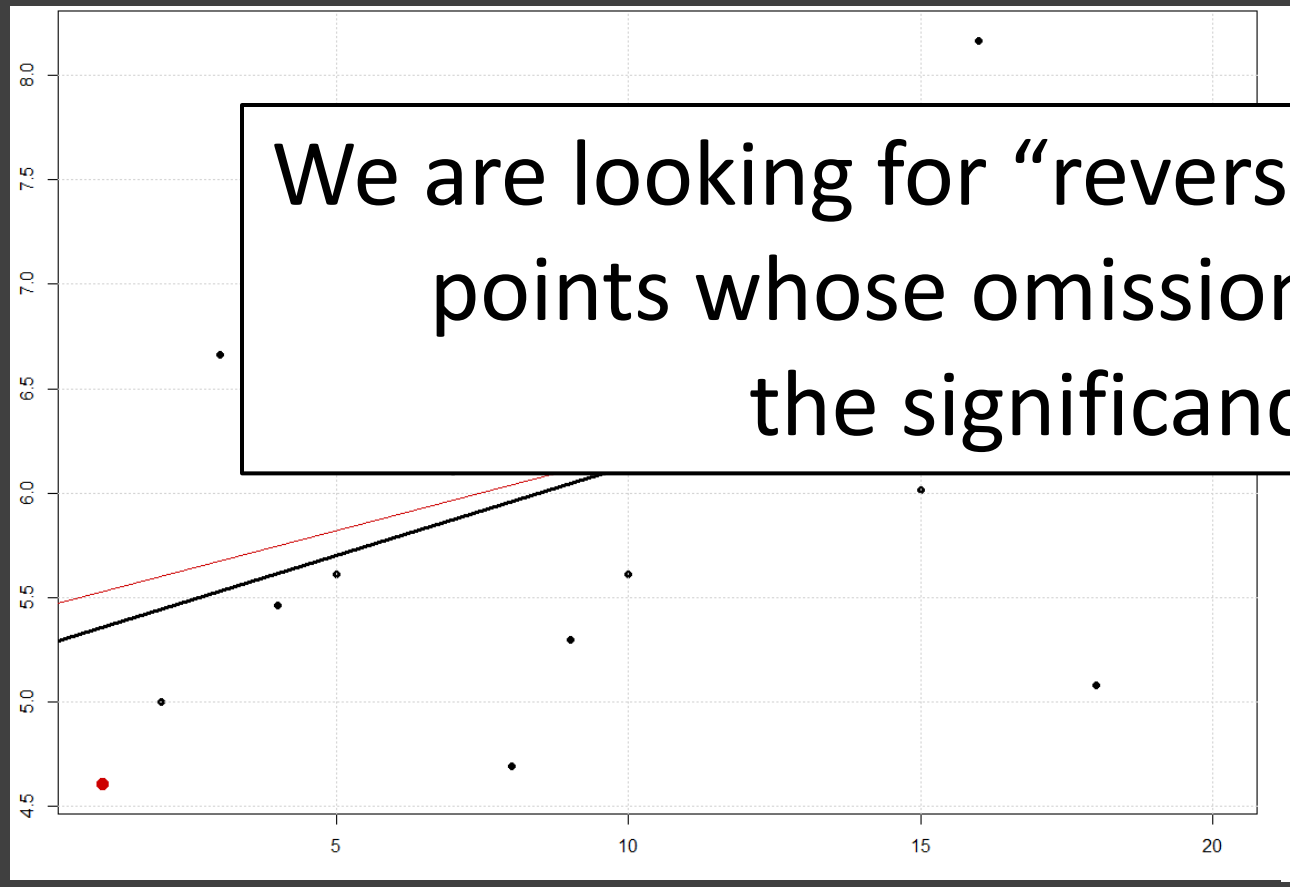
"We found a statistically significant association between *Cyp46a1* and *Abcg1* mRNA expression during pNET tumorigenesis"

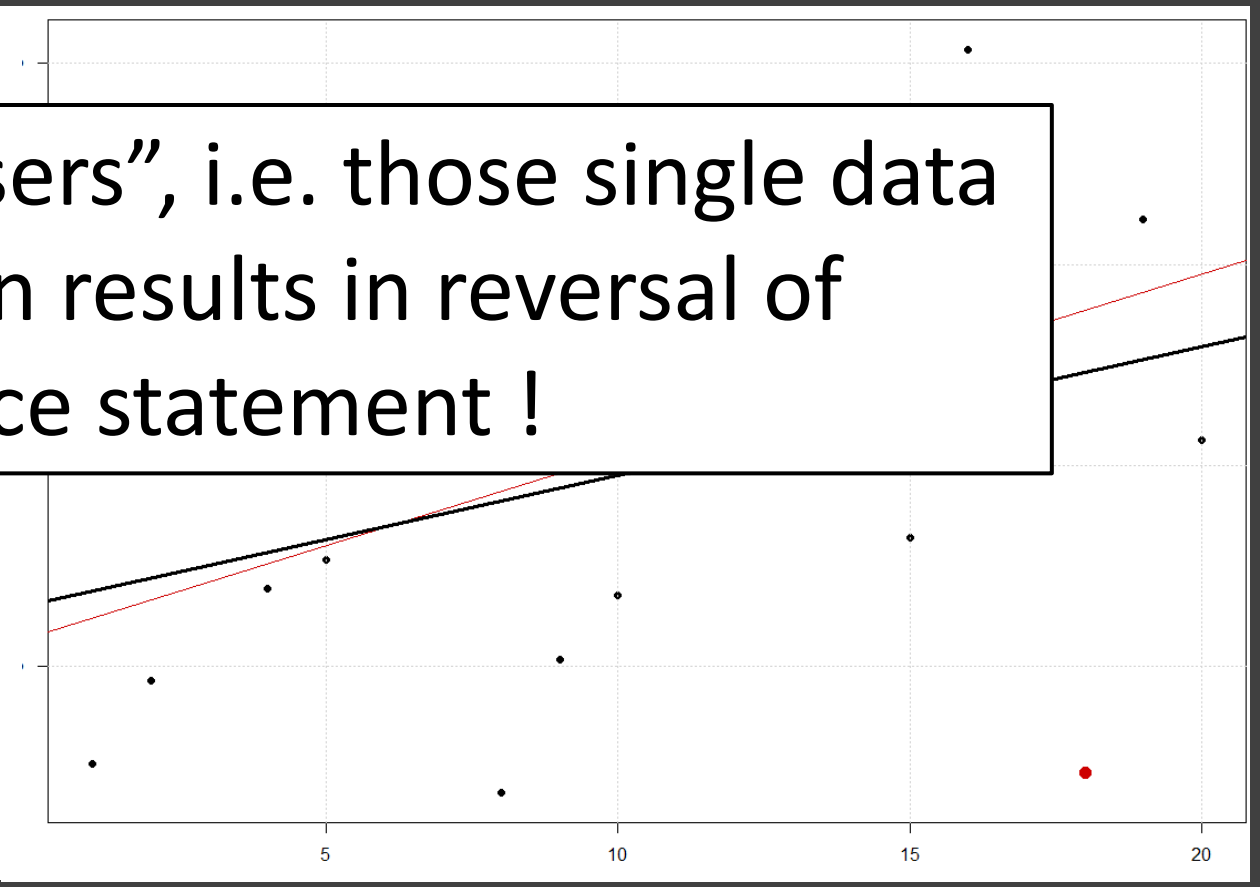
0.05

$p = 0.02$ → $p = 0.063$

0.05

$p = 0.012$ ← $p = 0.115$





We are looking for “reversers”, i.e. those single data points whose omission results in reversal of the significance statement !

	Formula	Cut-off	
Leverage	$h_{ii} = x_i'(X'X)^{-1}x_i$	$h_{ii} > 2\bar{h} = \frac{2k}{n}$	Outlyingness on the X-axis
Cook's D	$D_i = \frac{(b_i - b_{(i)})'X'X(b_i - b_{(i)})}{}$	$D_i > F_{0.5}(k, n-k)$	Moved vector of fitted values
DFBETAS	DFE		ange of regression efficients
	$\sqrt{S_{(i)}C_{jj}}$		
	$\sqrt{S_{(i)}^2 h_{ii}}$		
Covratio	$COVRATIO_i = \frac{}{MS_{res}^k\left(\frac{}{1-h_{ii}}\right)}$	$COVRATIO_i > 1 + \frac{3k}{n}$	Precision of estimation
Stud. Res.	$t_i = \frac{y_i - \hat{y}_{(i)}}{\hat{\sigma}_{(i)}(1 + x_i^T(X_{(i)}^T X_{(i)})x_i)^{1/2}}$	$t_i > Q_t(0.975, n - p - 1)$	Outlyingness on the Y-axis

None of these measures relates to changes in the *p*-value !!

$$\Delta p = p_{\beta 1} - p_{\beta 1(i)} = 2\left(1 - P_t(t_{\beta 1}, \nu)\right) - 2\left(1 - P_t(t_{\beta 1(i)}, \nu - 1)\right)$$

$$\alpha \in \left[p_{\beta 1}, p_{\beta 1(i)}\right]$$

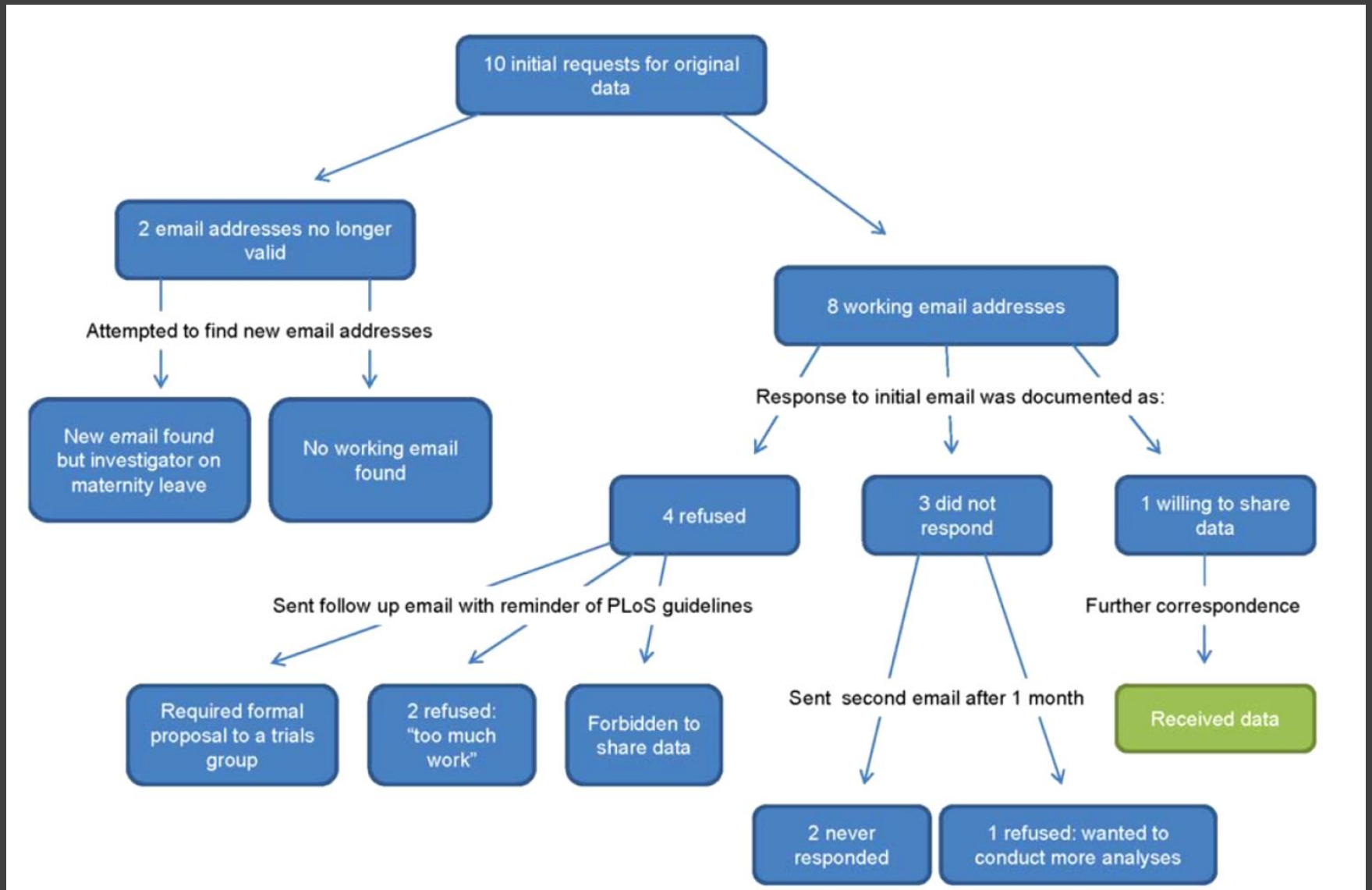
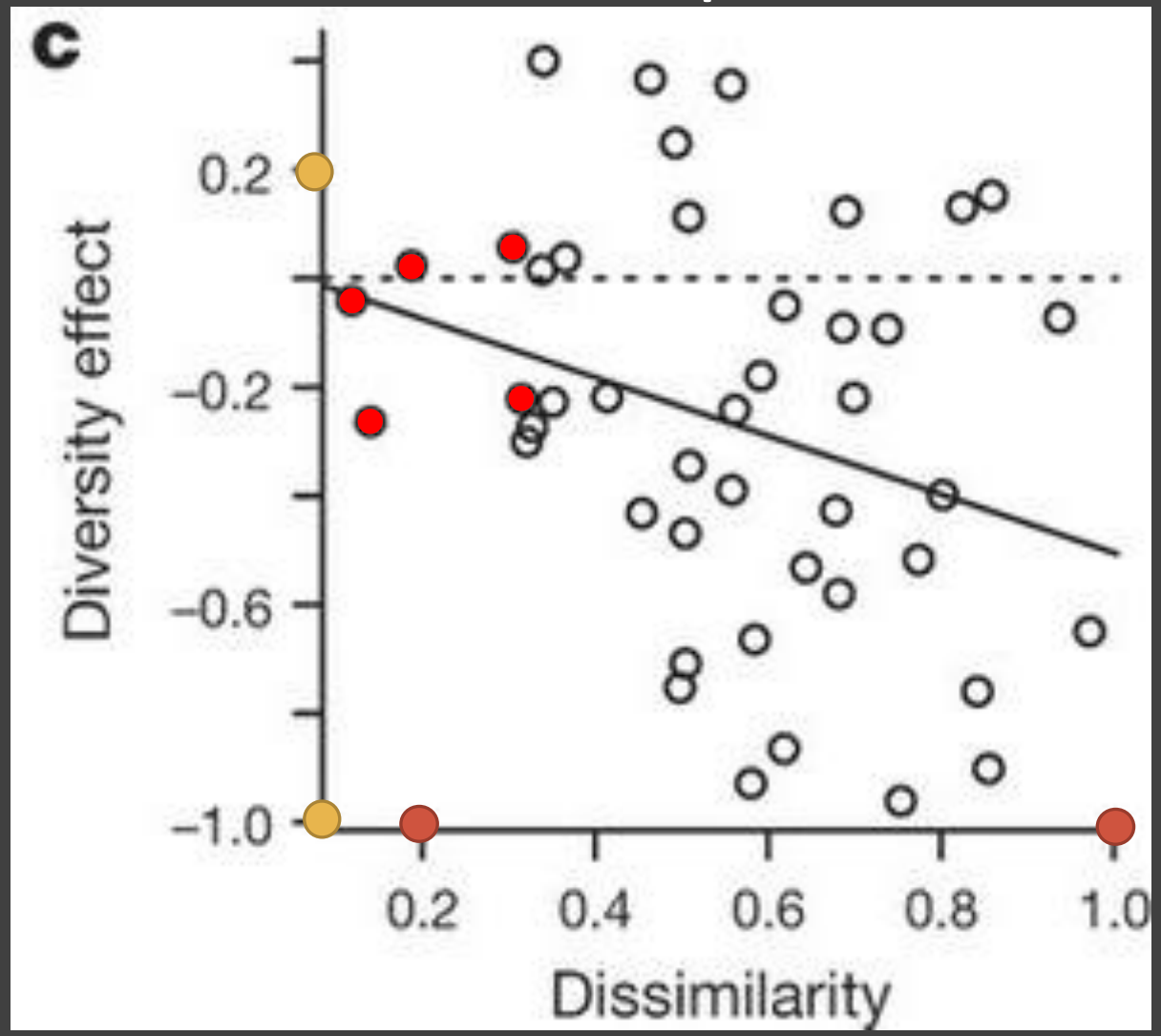


Figure 1. Summary of responses to the 10 initial requests for raw data.
doi:10.1371/journal.pone.0007078.g001

A paper in *Science* 2016

$n = 45$ $R^2 = 0.1$ $p = 0.04$



?

WebPlotDigitizer
Web based tool to extract data from plots, images, and maps

x	y
0.120	-0.040
0.142	-0.261
0.189	0.023
0.307	0.057
0.317	-0.224
...	

→ Linear Regression

C:/science/R-3.5.0/library/reverseR/reverseR - Shiny

http://127.0.0.1:4280 | Open in Browser | Publish

Detection of Significance Reversers in Linear Regression

Data format

The expected input data is a **.csv** spreadsheet with **two** or **three** columns (x-values in first, y-values in second, optional weights in third), with the variable names in the first row (see below):

Time	Fluo	Weights (optional)
4.2	17.22	0.15
5.7	22.31	0.07
...	...	...

Example

(Figure of a 2015 PNAS paper)

Example

Import Data

Data has a Header row

Type of decimal sign

dot (.)

comma (,)

Type of separator

comma (,)

space (\s)

tab (\t)

Statistics | Regression Plot | P-Value Plot | Slope vs. SE Plot | Influence Plot | Leave-Multiple-Out Plot

New Observation Analysis

Message:

(The message 'Error: incorrect number of dimensions' would indicate wrong import parameters)

```
Significant model with p = 0.0406417 has been changed to insignificant by removing one of the followin
g data points (in order of strength):

#41 => 0.08304431
#44 => 0.07207993
#40 => 0.07040441
#9 => 0.06926967
#36 => 0.06551448
#3 => 0.05974426
#4 => 0.05726832
#1 => 0.05400165
#8 => 0.05351361
#11 => 0.05298364
#37 => 0.05187982
```

Summary of full model (all da

```
Call:
lm(formula = DAT[, 2] ~ DAT[, 1], weights = wts)

Residuals:
     Min       1Q   Median       3Q      Max
-0.65061 -0.22042 -0.04951  0.24795  0.62305

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.03401    0.15271   0.223   0.8249
DAT[, 1]    -0.54034    0.25580  -2.112   0.0406 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.3519 on 42 degrees of freedom
Multiple R-squared:  0.09604,   Adjusted R-squared:  0.07451
F-statistic: 4.462 on 1 and 42 DF,  p-value: 0.04064
```

Statistical Analysis for each Leave-One-Out model. For abbreviations, see below Table.

$$S = 1 - \frac{n_r}{N} = 1 - \frac{11}{45} = 0.76$$

C:/science/R-3.5.0/library/reverseR/reverseR - Shiny

http://127.0.0.1:4280 | Open in Browser

Detection of Significance Revers

Statistics | Regression Plot | P-Value Plot

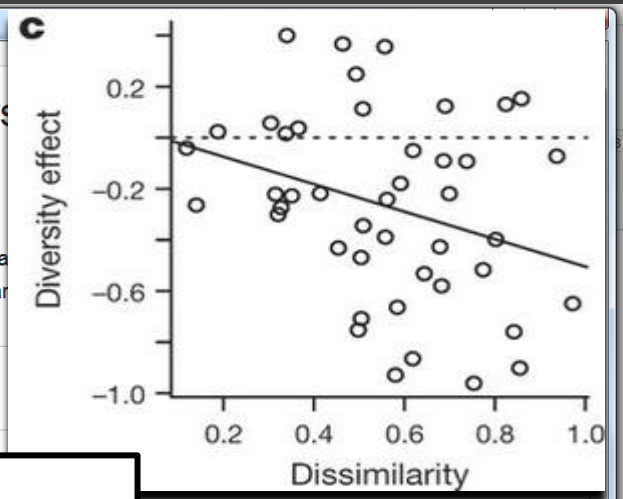
New Observation Analysis

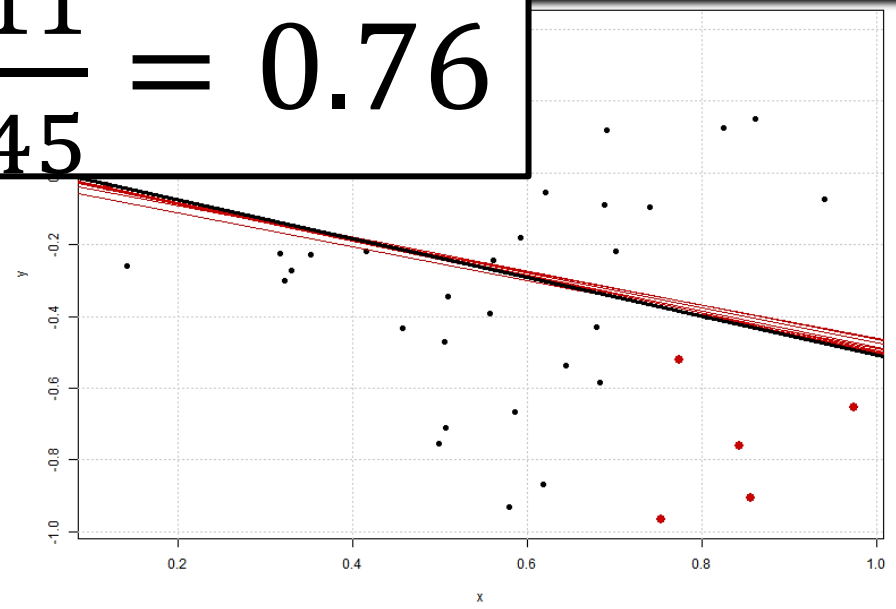
Linear Regression Plot with Influential Data

Significance reversers are depicted with lar

Mouse over data point to see its x/y value.

```
Data under cursor:
No data point.
```





PNAS paper)

Example

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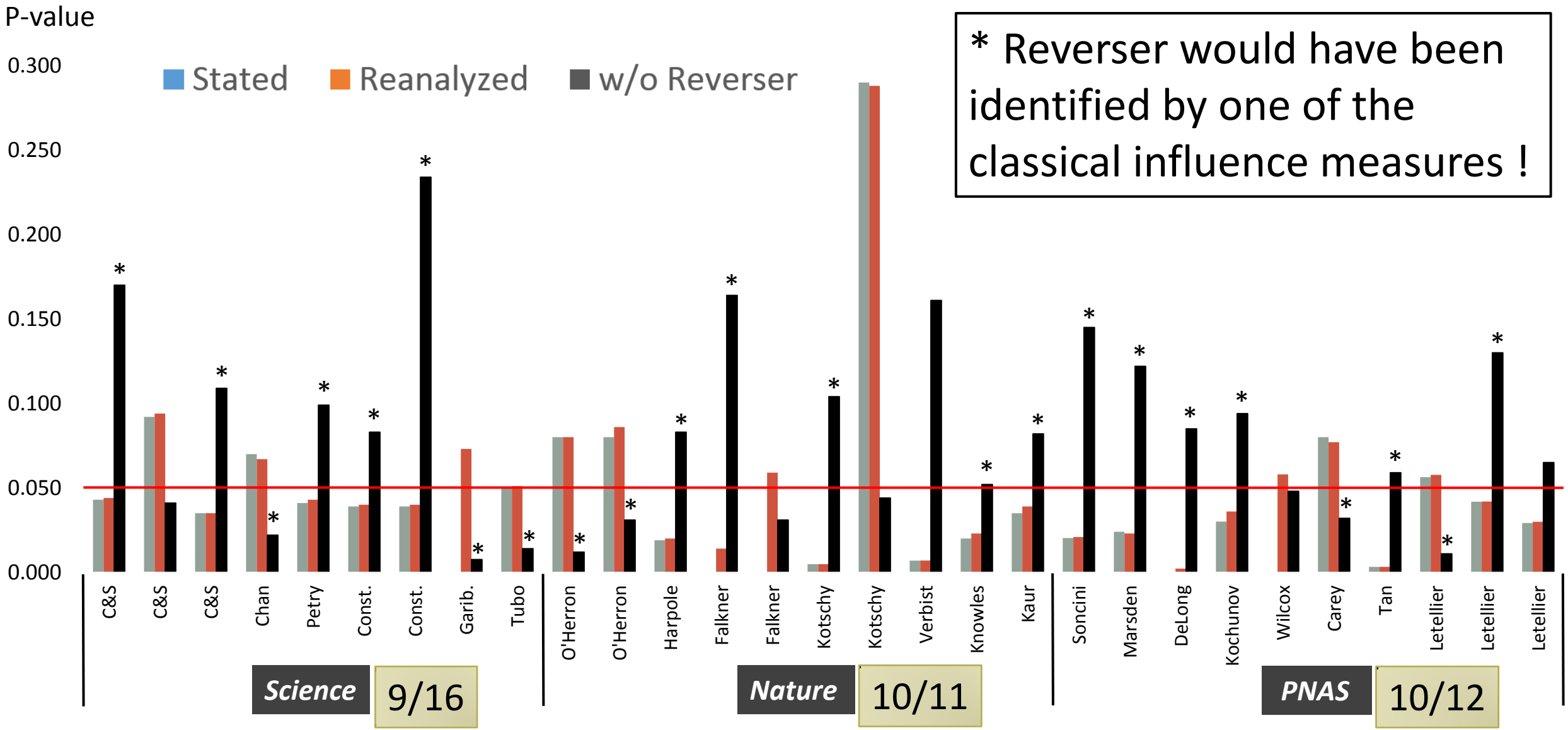
semicolon (;)


P-value
0.300
0.250
0.200
0.150
0.100
0.050
0.000
Stated
Reanalyzed
w/o Reverser
* Reverser would have been identified by one of the classical influence measures !
C&S
C&S
C&S
Chan
Petry
Const.
Const.
Garib.
Tubo
O'Herron
O'Herron
Harpole
Falkner
Falkner
Kotschy
Kotschy
Verbist
Knowles
Kaur
Soncini
Marsden
DeLong
Kochunov
Wilcox
Carey
Tan
Letellier
Letellier
Letellier
Science
9/16
Nature
10/11
PNAS
10/12

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Institute for Medical Biometry and Statistics, Universitätsklinikum Schleswig-Holstein, Lübeck, Germany