Cohen w (es_cohen_w)

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Introduction

The *es_cohen_w* function (and *es_cohen_w_arr* in VBA) calculates the effect size Cohen w for a goodness-of-fit test.

This document contains the details on how to use the functions, and formulas used in them.

1 About the Function

1.1 Input parameters:

- **chi2**
  the chi-square test statistic.

- **n**
  the sample size

- *Optional parameters*
  - **out** (default is “value”) – only applies to VBA *es_cohen_w*
    Choice what to show as result. Either:
    - “value”: the effect size value
    - “qual”: the qualification/classification of the value

1.2 Output:

- **Value**
  The Cohen’s w value

- **Qualification**
  The qualification/classification of the effect size using a rule of thumb

- The array version in VBA (*es_cohen_w_arr*) requires **two rows** and **two columns**.

1.3 Dependencies

- **Excel**
  None.
  You can run the **es_cohen_w_addHelp** macro so that the function will be available with some help in the 'User Defined' category in the functions overview.

- **Python**
  The following additional libraries will have to be installed/loaded:
  - *pandas*
    the data input needs to be a pandas data series, and the output is also a pandas dataframe.

- **R**
  No other libraries required.

2 Examples

2.1 Excel

	A	B	C	D	E	F
1						
2						
3		chi-square value:		3,105263		
4		sample size:		19		
5						
6		**out**				
7		*value*	0,40427082	=es_cohen_w(D3;D4;B7)		
8		*qual*	medium	=es_cohen_w(D3;D4;B8)		
9						
10		Cohen's w	Qualification			
11		0,40427082	medium			
12						
13		B10:C11 =>	=es_cohen_w_arr(D3;D4)			

2.2 Python

```
[2]: chi2 = 3.105263
     n = 19

     es_cohen_w(chi2, n)
```

[2]:

	Cohen's w	Classification
0	0.404271	medium

2.3 R

```
> chi2Value <- 3.105263
> n <- 19
> es_cohen_w_arr(chi2Value, n)
          w   qual
1 0.4042708 medium
>
```

3 Details of Calculations

3.1 The Effect Size

$$w = \sqrt{\frac{\chi^2_{GoF}}{n}}$$

Where:

χ^2_{GoF} the Pearson chi-square goodness-of-fit value (see section **Error! Reference source not found.**)

n the sample size, i.e. the sum of all frequencies

Cramér's V can be determined from w using:

$$v = \frac{w}{\sqrt{k-1}}$$

3.2 Interpretation

Table 1

Rule of thumb for Cohen w interpretation

Cohen's w	*Interpretation*
0.00 < 0.10	Negligible
0.10 < 0.30	Small
0.30 < 0.50	Medium
0.50 or more	Large

Note. Adapted from Cohen (1988, pp. 224–225)

4 Sources

Cohen's w can be found in *Statistical power analysis for the behavioral sciences* (2nd ed) (Cohen, 1988), on page 216:

crepancy between these paired proportions over the cells in the following way:

(7.2.1) $$\mathbf{w} = \sqrt{\sum_{i=1}^{m} \frac{(\mathbf{P}_{1i} - \mathbf{P}_{0i})^2}{\mathbf{P}_{0i}}},$$

Note: Cohen actually uses in the expression under the square root:

$$\sum_{i=1}^{k} \frac{(p_i - q_i)^2}{q_i}$$

Where:

- p_i the proportion of the i-th category
- q_i the expected proportion of the i-th category
- k the number of categories
- n the sample size, i.e. the sum of all frequencies

A proof for this:

$$\sum_{i=1}^{k}\frac{(p_i-q_i)^2}{q_i}=\sum_{i=1}^{k}\frac{\left(\frac{F_i}{n}-\frac{E_i}{n}\right)^2}{\frac{E_i}{n}}=\sum_{i=1}^{k}\frac{\left(\frac{F_i-E_i}{n}\right)^2}{\frac{E_i}{n}}=\sum_{i=1}^{k}\frac{\frac{(F_i-E_i)^2}{n^2}}{\frac{E_i}{n}}=\sum_{i=1}^{k}\frac{n\times(F_i-E_i)^2}{n^2\times E_i}$$
$$=\sum_{i=1}^{k}\frac{(F_i-E_i)^2}{n\times E_i}=\frac{1}{n}\times\sum_{i=1}^{k}\frac{(F_i-E_i)^2}{E_i}=\frac{1}{n}\times\chi_{GoF}^2=\frac{\chi_{GoF}^2}{n}$$

Cohen’s classification for his w:

small:	$\mathbf{w} = .10$,
medium:	$\mathbf{w} = .30$,
large:	$\mathbf{w} = .50$.

(Cohen, 1988, p. 227)

References

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). L. Erlbaum Associates.