

# O'Connell-Dobson-Schouten estimators of agreement applied to Landis and Koch (1976)

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## Abstract

This vignette applies the O'Connell-Dobson-Schouten estimators of agreement to a classical set of data on inter-rater agreement from Landis and Koch (1976). The analysis here follows the analysis given in O'Connell and Dobson (Biometrics 1984; 40: 973–983) and Schouten (Statistica Neerlandica 1982: 36: 45-61). We propose that the O'Connell-Dobson-Schouten estimators are valuable and encourage their broader use.

*Keywords:* agreement.

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O'Connell and Dobson (1984) and Schouten (1982) provide a technical discussion on the statistical properties of averaged measures of agreement, particularly un-weighted and weighted kappa statistics that adjust for the probability of chance agreement. Such measures of agreement are common for studies of multi-rater agreement with nominal or ordinal variables. We have adapted the Fortran code from the 1984 paper by O'Connell and Dobson for use in R and implemented the algorithms described by Schouten (1982) in Fortran. In the following, we apply the resulting package to the dataset analysed in both articles. We propose that the O'Connell-Dobson-Schouten estimators are valuable and encourage their broader use.

Landis and Koch (Biometrics 1977; 33: 363–374) provide a dataset on inter-rater agreement by seven pathologists for classifying carcinoma in situ for uterine cancer. The data are included in the **magree** package as the **landis** data, which is a matrix.

After loading the package, we can produce summary statistics for  $i=1$ , which is the un-weighted analysis, for the linear weights ( $i=2$ ) or for quadratic weights ( $i=3$ ). The summary statistics include marginal summaries and  $\hat{S}_{av}$  for each slide.

```
> require(magree)
> ## Table 1 (O'Connell and Dobson, 1984)
> summary(fit <- oconnell(landis, weight="unweighted"))
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

```
Sav(hetero):          0.361290 (se: 0.028881; 95% CI: 0.306811, 0.419587)
Sav(homoge):          0.354335 (se: 0.030018; 95% CI: 0.297924, 0.415112)
Pr(Overall agreement due to chance | hetero):          < 2.22e-16
Pr(Overall agreement due to chance | homoge):          < 2.22e-16
```

```
Observed marginal distributions for categories:
```

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	1	2	3	4	5
	0.28087167	0.25423729	0.36440678	0.07384988	0.02663438

Observed marginal distributions for categories by observer:

	1	2	3	4	5
A	0.2203390	0.2203390	0.3220339	0.186440678	0.050847458
B	0.2288136	0.1016949	0.5847458	0.059322034	0.025423729
C	0.2627119	0.3559322	0.3135593	0.050847458	0.016949153
D	0.3220339	0.4067797	0.1949153	0.067796610	0.008474576
E	0.1355932	0.2627119	0.4491525	0.118644068	0.033898305
F	0.5254237	0.2627119	0.1694915	0.008474576	0.033898305
G	0.2711864	0.1694915	0.5169492	0.025423729	0.016949153

Agreement statistics  $S_i$  for each subject:

	1	2	3	4	5	6
0.08088076	1.00000000	1.00000000	0.34348626	1.00000000	0.34348626	
7	8	9	10	11	12	
0.60609175	0.21218351	0.27783488	0.60609175	0.60609175	0.60609175	
13	15	16	17	18	19	
0.60609175	0.21218351	0.08088076	0.60609175	0.21218351	0.21218351	
22	23	24	25	26	27	
0.08088076	0.60609175	0.34348626	0.34348626	1.00000000	0.34348626	
28	29	30	31	32	33	
0.08088076	0.34348626	0.60609175	1.00000000	0.27783488	1.00000000	
34	35	36	37	38	39	
1.00000000	0.27783488	0.27783488	0.08088076	0.01522939	0.34348626	
40	41	42	43	44	45	
0.08088076	0.60609175	1.00000000	0.08088076	0.27783488	0.60609175	
46	47	48	49	51	52	
-0.05042199	0.21218351	0.34348626	0.08088076	0.60609175	0.27783488	
53	54	55	56	57	58	
0.27783488	0.01522939	0.60609175	0.60609175	0.01522939	1.00000000	
59	60	61	62	63	64	
1.00000000	0.60609175	0.08088076	0.27783488	0.08088076	0.21218351	
65	66	67	68	69	70	
0.60609175	0.08088076	1.00000000	0.34348626	0.27783488	1.00000000	
71	72	73	74	76	77	
0.60609175	0.27783488	0.60609175	0.01522939	0.60609175	0.34348626	
78	79	80	81	82	83	
0.08088076	0.34348626	-0.11607336	1.00000000	0.21218351	0.08088076	
84	85	86	87	88	89	
0.27783488	-0.18172474	0.60609175	0.60609175	0.01522939	-0.11607336	
90	91	92	93	94	95	
0.08088076	0.01522939	-0.11607336	0.21218351	0.34348626	0.27783488	

	96	98	99	100	101	102
-0.11607336	0.21218351	0.21218351	0.08088076	0.34348626	0.34348626	
	103	104	105	106	107	108
1.00000000	0.01522939	0.60609175	0.08088076	0.21218351	0.08088076	
	110	111	112	113	114	115
0.21218351	0.60609175	0.21218351	0.08088076	0.08088076	0.21218351	
	116	117	118	119	120	121
0.60609175	0.34348626	0.08088076	0.60609175	1.00000000	0.21218351	
	122	123	124	126		
-0.11607336	-0.11607336	0.60609175	0.01522939			

A simple print of the object provides a short description of the estimator. This is shown here for the linear and quadratic weights.

```
> ## Table 1 (O'Connell and Dobson, 1984), continued
> print(update(fit, weight="linear"))
```

O'Connell-Dobson-Schouten estimator (linear weights)

```
Sav(hetero):      0.515924 (se: 0.034694; 95% CI: 0.448050, 0.583216)
Sav(homoge):      0.509672 (se: 0.036048; 95% CI: 0.439295, 0.579667)
Pr(Overall agreement due to chance | hetero):      < 2.22e-16
Pr(Overall agreement due to chance | homoge):      < 2.22e-16
```

```
> print(update(fit, weight="quadratic"))
```

O'Connell-Dobson-Schouten estimator (quadratic weights)

```
Sav(hetero):      0.646884 (se: 0.039399; 95% CI: 0.566433, 0.719791)
Sav(homoge):      0.641728 (se: 0.040832; 95% CI: 0.558428, 0.717270)
Pr(Overall agreement due to chance | hetero):      < 2.22e-16
Pr(Overall agreement due to chance | homoge):      < 2.22e-16
```

Table 3 of O'Connell and Dobson (1984) includes an analysis where the slides are grouped by level of disagreement. We reproduce the table here.

```
> slideTypeGroups <-
+   list(c(2,3,5,26,31,34,42,58,59,67,70,81,103,120),
+        c(7,10:13,17,23,30,41,51,55,56,60,65,71,73,76,86,87,105,111,116,119,124),
+        c(4,6,24,25,27,29,39,48,68,77,79,94,101,102,117),
+        c(9,32,36,44,52,62,84,95),
+        c(35,53,69,72),
+        c(8,15,18,19,47,64,82,93,98,99,107,110,112,115,121),
+        c(1,16,22,49,63,66,78,90,100,113),
+        c(28,37,40,61,108,114,118),
+        106,
```

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```
+      43,
+      83,
+      c(54,57,88,91,126),
+      c(74,104),
+      38,
+      46,
+      c(89,122),
+      c(80,92,96,123),
+      85)
```

The average  $\hat{S}_i$  in those groups can be readily calculated by:

```
> data.frame(SlideType=1:18,
+           S1=sapply(slideTypeGroups,
+                   function(ids) mean(fit$s1[as.character(ids)])),
+           S2=sapply(slideTypeGroups,
+                   function(ids) mean(fit$s2[as.character(ids)])))
```

	SlideType	S1	S2
1	1	1.00000000	1.00000000
2	2	0.60609175	0.601802471
3	3	0.34348626	0.336337452
4	4	0.27783488	0.269971197
5	5	0.27783488	0.269971197
6	6	0.21218351	0.203604942
7	7	0.08088076	0.070872432
8	8	0.08088076	0.070872432
9	9	0.08088076	0.070872432
10	10	0.08088076	0.070872432
11	11	0.08088076	0.070872432
12	12	0.01522939	0.004506178
13	13	0.01522939	0.004506178
14	14	0.01522939	0.004506178
15	15	-0.05042199	-0.061860077
16	16	-0.11607336	-0.128226332
17	17	-0.11607336	-0.128226332
18	18	-0.18172474	-0.194592587

which follows part of Table 2. Finally, Table 5 from O'Connell and Dobson (1984) can be easily reproduced by dichotomising the outcomes:

```
> magree(landis==1)
```

O'Connell-Dobson-Schouten estimator (unweighted)

```
Sav(hetero):      0.563058 (se: 0.043851; 95% CI: 0.476079, 0.646324)
Sav(homoge):      0.558453 (se: 0.045153; 95% CI: 0.469036, 0.644234)
```

```
Pr(Overall agreement due to chance | hetero): < 2.22e-16
Pr(Overall agreement due to chance | homoge): < 2.22e-16
```

```
> magree(landis==2)
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

```
Sav(hetero):      0.159782 (se: 0.029600; 95% CI: 0.109879, 0.226580)
Sav(homoge):      0.152886 (se: 0.030545; 95% CI: 0.102073, 0.222719)
Pr(Overall agreement due to chance | hetero):      7.1863e-14
Pr(Overall agreement due to chance | homoge):      3.8278e-11
```

```
> magree(landis==3)
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

```
Sav(hetero):      0.373709 (se: 0.036869; 95% CI: 0.304686, 0.448289)
Sav(homoge):      0.364046 (se: 0.038646; 95% CI: 0.292140, 0.442584)
Pr(Overall agreement due to chance | hetero):      < 2.22e-16
Pr(Overall agreement due to chance | homoge):      < 2.22e-16
```

```
> magree(landis==4)
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

```
Sav(hetero):      0.180271 (se: 0.043233; 95% CI: 0.110276, 0.280679)
Sav(homoge):      0.173971 (se: 0.043852; 95% CI: 0.103787, 0.276947)
Pr(Overall agreement due to chance | hetero):      < 2.22e-16
Pr(Overall agreement due to chance | homoge):      1.8569e-14
```

```
> magree(landis==5)
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

```
Sav(hetero):      0.626828 (se: 0.145957; 95% CI: 0.330852, 0.850890)
Sav(homoge):      0.626413 (se: 0.146334; 95% CI: 0.329882, 0.850997)
Pr(Overall agreement due to chance | hetero):      < 2.22e-16
Pr(Overall agreement due to chance | homoge):      < 2.22e-16
```

We can also compare the raters using the results due to Schouten (1982).

```
> fit2 <- magree(landis)
> summary(fit2)
```

```
O'Connell-Dobson-Schouten estimator (unweighted)
```

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Observed marginal distributions for categories by observer:

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C	0.2627119	0.3559322	0.3135593	0.050847458	0.016949153
D	0.3220339	0.4067797	0.1949153	0.067796610	0.008474576
E	0.1355932	0.2627119	0.4491525	0.118644068	0.033898305
F	0.5254237	0.2627119	0.1694915	0.008474576	0.033898305
G	0.2711864	0.1694915	0.5169492	0.025423729	0.016949153

Agreement statistics  $S_i$  for each subject:

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	7	8	9	10	11	12
	0.60609175	0.21218351	0.27783488	0.60609175	0.60609175	0.60609175
	13	15	16	17	18	19
	0.60609175	0.21218351	0.08088076	0.60609175	0.21218351	0.21218351
	22	23	24	25	26	27
	0.08088076	0.60609175	0.34348626	0.34348626	1.00000000	0.34348626
	28	29	30	31	32	33
	0.08088076	0.34348626	0.60609175	1.00000000	0.27783488	1.00000000
	34	35	36	37	38	39
	1.00000000	0.27783488	0.27783488	0.08088076	0.01522939	0.34348626
	40	41	42	43	44	45
	0.08088076	0.60609175	1.00000000	0.08088076	0.27783488	0.60609175
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	-0.05042199	0.21218351	0.34348626	0.08088076	0.60609175	0.27783488
	53	54	55	56	57	58
	0.27783488	0.01522939	0.60609175	0.60609175	0.01522939	1.00000000
	59	60	61	62	63	64
	1.00000000	0.60609175	0.08088076	0.27783488	0.08088076	0.21218351
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	0.60609175	0.08088076	1.00000000	0.34348626	0.27783488	1.00000000
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	0.60609175	0.27783488	0.60609175	0.01522939	0.60609175	0.34348626

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0.27783488	-0.18172474	0.60609175	0.60609175	0.01522939	-0.11607336	
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0.08088076	0.01522939	-0.11607336	0.21218351	0.34348626	0.27783488	
	96	98	99	100	101	102
-0.11607336	0.21218351	0.21218351	0.08088076	0.34348626	0.34348626	
	103	104	105	106	107	108
1.00000000	0.01522939	0.60609175	0.08088076	0.21218351	0.08088076	
	110	111	112	113	114	115
0.21218351	0.60609175	0.21218351	0.08088076	0.08088076	0.21218351	
	116	117	118	119	120	121
0.60609175	0.34348626	0.08088076	0.60609175	1.00000000	0.21218351	
	122	123	124	126		
-0.11607336	-0.11607336	0.60609175	0.01522939			

Agreement statistics for each observer:

	Kappa	[Lower	Upper]	Pr(kappa_av=kappa_observer)
A	0.37274	0.30394	0.4471	0.60718
B	0.40591	0.33691	0.4788	0.03444 *
C	0.38173	0.31292	0.4556	0.40306
D	0.33866	0.27026	0.4145	0.33175
E	0.32894	0.25801	0.4086	0.23888
F	0.24269	0.17536	0.3257	< 1e-05 ***
G	0.46538	0.40385	0.5280	< 1e-05 ***

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Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

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