Summary of the North Carolina NCEXTEND2 Concordance Science

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General Summary and Notes

The concordances between the NCEXTEND2 and Edition 4 Science End-of-Grade (EOG) tests for grades 3-8 and the Biology End-of-Course (EOC) test were created by Dr. Joshua Goodman from August 10th to August 19th 2013, with oversight and review by Dr. Alan Nicewander. Each concordance table was created using chained equipercentile[1] linking with bivariate frequency distributions were pre-smoothed using log-linear methods (Holland & Thayer, 1987; 2000),.

General notes

- Concordances were made between number correct scores on the NCEXTEND2 and number correct scores on the general test.
- The NCEXTEND2 is administered using online and paper modalities. Given the small sample size on the paper version of the test, the concordance was created using the online version exclusively (form M)[2].
- A single form of each EOG/EOC was used to create the concordances.
- Number correct scores for the NCEXTEND2 test, the general test, and the scaling test, administered to both samples, were provided by NCDPI.
- Standard errors of equating (SEE) were generated using bootstrap methods with 500 replications.
- Concordances were conducted in the R statistical programming language using programs written by Dr. Goodman and supplemented with the R package "equate" (Albano, 2011).

Summary Statistics for NCEXTEND2 and General Test Populations

Table 1 displays descriptive statistics for both populations of students who were administered the scaling test for each grade level. Statistics for the NCEXTEND2, general test, and the scaling tests are included.

[1] Due to the large difference in the population, linking methods which rely on a synthetic population (e.g., frequency estimation methods, Tucker and Levine linear methods) were deemed inappropriate. For a discussion of why these methods are not recommended when group differences are large see Macro, 1983; Harris & Kolen, 1990; Wang et al, 2006; Sinharay & Holland, 2006.

[2] This decision was made in conjunction with NCDPI.

Table 1: Descriptive Statistics for Each Test

Grade	Population	N	Test (form)	Total Items	Min	Max	Mean	SD	Skew	Kurtosis	Cov.	Cor.
5	NCEXTEND2	1144	NCEXTEND2(M)	48	8	43	23.73	6.75	0.15	2.45	19.10	0.68
			Scaling	30	2	28	12.34	4.19	0.44	3.11		
	General	1002	EOG(M)	60	11	60	39.46	10.45	-0.40	2.30	35.95	0.81
			Scaling	30	8	30	20.44	4.27	-0.43	2.65		
8	NCEXTEND2	926	NCEXTEND2(M)	46	5	42	22.72	6.17	0.34	2.95	11.11	0.48
			Scaling	30	0	24	11.27	3.78	0.07	3.70		
	General	421	EOG(M)	60	12	59	33.88	10.84	0.12	2.25	40.94	0.75
			Scaling	30	0	28	17.92	5.04	-0.76	4.57		
BIO	NCEXTEND2	307	NCEXTEND2(M)	46	9	41	22.92	6.39	0.39	2.67	13.29	0.51
			Scaling	30	0	23	11.07	4.11	-0.26	3.85		
	General	136	EOC(M)	60	15	60	39.40	10.81	-0.24	2.25	43.46	0.68
			Scaling	30	0	27	18.79	5.88	-1.44	5.31		

Smoothing and Concordance Creation

When linking using percentile ranks based on samples of students, sampling errors often interfere with the precise estimation of the linking relationship. One way to reduce the impact of sampling errors on linking is to smooth the score distribution to better estimate the distribution of the population. By doing so, it is possible to more precisely estimate the linking relationship in the population and thus reduce the total amount of error reduced. When deciding how to smooth the distribution, it is also important to ensure that some of the moments of the observed distribution are preserved and does not vary significantly from linking based on the observed score distribution. In the creation of the NCEXTEND2 concordance tables, the following method was used to select a smoothed score distribution:

1. For both groups, nine different log-linear smoothing (preserving 1 to 9 moments) were fit to the observed frequencies.
2. Models were determined analytically for each group using a combination of two chi-square likelihood ratio (G^2) tests (see tables A.1 through A.3 for summaries).
    a. The first significance assessed if the smoothed curve adequately fit the unsmoothed distribution ($p>0.05$ indicated adequate fit).
    b. The second tested if there was significant incremental improvement over less restrictive smoothing models ($p<0.05$ indicates improvement over the prior log-linear model).
    c. The least restrictive (i.e., preserving the fewest moments) log-liner model that met both criteria was selected as the initial smoothed bivariate distribution.
    d. If no log-linear model met both criteria, the initial smoothing criteria was set to C=4.
3. After the selection of a model, chained equipercentile methods were used to create concordances for both the unsmoothed and smoothed score distributions.
4. A 95% confidence interval was placed around the unsmoothed linking relationship (using standard errors of equating at each observed score point).
5. If the smoothed concordance falls outside of the confidence interval, additional smoothing was applied to one of the score distributions. This was done by selecting the least smoothed score distribution and fitting a log-linear model that increased the moments preserved by one.
6. Steps 4 and 5 were repeated until the smoothed linking function fell within the confidence interval at all observed score points.

Figures A.1 through A.3 depict the original bivariate distributions and the final smoothed distributions and Figures A.4 through A.6 display the concordances based on the unsmoothed, initially smoothed, and final smoothed frequencies for each grade. Table 2 contains summary statistics of the transformed NCEXTEDN2 score distributions.

Tables A.4 through A.6 contain each possible NCEXTEND2 number correct score, its associated EOG/EOC equivalent, and SEE for concordances created using both smoothed and unsmoothed score distributions. To create the final concordance table for grade, the EOG/EOC equivalent scores for each NCEXTEND2 raw scores (from the concordance based on the final smoothed distribution) were rounded to the nearest integer. These final tables are summarized for each grade in Table 3.

Table 2: Number of Bivariate Moments Preserved

Grade	Concordance	C* (EX2)	C* (EOG)	Mean	SD	Skew	Kurtotsis
5	Unsmoothed	0	0	19.528	10.724	0.026	3.416
	First Smooth	2	2	19.345	10.223	0.225	2.648
	Final Smooth	9	9	20.411	9.284	0.616	3.661
8	Unsmoothed	0	0	20.08	5.91	1.64	6.32
	First Smooth	2	2	19.63	7.99	0.12	2.81
	Final Smooth	7	6	19.97	5.96	1.64	6.10
Bio	Unsmoothed	0	0	24.30	5.65	1.08	4.83
	First Smooth	2	2	25.16	7.69	-0.02	2.97
	Final Smooth	5	4	24.84	4.58	2.06	10.58

*C refers to the number of marginal distribution moment retained.

Table 3: Final Concordance Tables

NCEXTEND2 Number Correct	EOG/EOC Equivalent Raw Score		
	5 (Form M)	8 (Form M)	Bio (Form M)
0	0	7	0
1	1	8	0
2	1	8	0
3	1	9	1
4	1	9	2
5	1	10	4
6	3	10	6
7	4	11	8
8	4	12	10
9	4	13	12
10	4	13	13
11	4	14	15
12	4	15	17
13	6	15	20
14	8	15	21
15	9	15	22
16	11	15	22
17	12	15	22
18	13	15	23
19	14	16	23
20	16	16	23
21	17	17	23
22	18	18	24
23	19	19	24

NCEXTEND2 Number Correct	EOG/EOC Equivalent Raw Score		
	5 (Form M)	8 (Form M)	Bio (Form M)
24	21	20	24
25	22	21	25
26	23	22	25
27	24	23	26
28	25	24	26
29	26	26	27
30	27	27	28
31	29	28	29
32	31	29	30
33	33	31	31
34	35	32	33
35	37	34	35
36	40	36	37
37	42	37	40
38	45	40	42
39	47	42	45
40	49	45	47
41	51	47	49
42	54	49	51
43	56	50	52
44	59	52	54
45	60	53	55
46	.	54	57

APPENDIX

Table A.1: Smoothing Results for C=1 to C=9: Grade 5

Moments Preserved	NCEXTEND2						General					
	Overall Fit			Incremental Fit			Overall Fit			Incremental Fit		
	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*
1	3783.331	1423	<0.001		.	.	2983.645	1888	<0.001		.	.
2	1409.889	1421	**0.578**	2373.443	1	**<0.001**	1761.954	1886	**0.980**	1221.692	1	**<0.001**
3	1369.842	1419	**0.822**	40.047	1	**<0.001**	1742.710	1884	**0.991**	19.244	1	**0.000**
4	1336.435	1417	**0.937**	33.407	1	**<0.001**	1638.509	1882	**0.999**	104.201	1	**<0.001**
5	1329.150	1415	**0.949**	7.286	1	**0.007**	1637.471	1880	**0.999**	1.039	1	0.308
6	1324.784	1413	**0.954**	4.366	1	**0.037**	1630.649	1878	**0.999**	6.822	1	**0.009**
7	1320.609	1411	**0.958**	4.175	1	**0.041**	1630.163	1876	**0.999**	0.485	1	0.486
8	1316.815	1409	**0.961**	3.794	1	0.051	1630.277	1874	**0.999**	-0.114	1	0.999
9	1314.247	1407	**0.962**	2.568	1	0.109	1630.232	1872	**0.999**	0.045	1	0.831

Table A.2: Smoothing Results for C=1 to C=9: Grade 8

Moments Preserved	NCEXTEND2						General					
	Overall Fit			Incremental Fit			Overall Fit			Incremental Fit		
	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*
1	3237.50	1454.00	0.00	.	.	.	1660.28	1888.00	**0.99**	.	.	.
2	996.02	1452.00	**0.99**	2241.48	1.00	**<0.001**	1115.99	1886.00	**0.99**	544.29	1.00	**<0.001**
3	976.77	1450.00	**0.99**	19.25	1.00	**<0.001**	1071.29	1884.00	**0.99**	44.70	1.00	**<0.001**
4	955.95	1448.00	**0.99**	20.83	1.00	**<0.001**	1045.63	1882.00	**0.99**	25.66	1.00	**<0.001**
5	926.44	1446.00	**0.99**	29.50	1.00	**<0.001**	1025.84	1880.00	**0.99**	19.80	1.00	**<0.001**
6	920.12	1444.00	**0.99**	6.32	1.00	**0.01**	1019.70	1878.00	**0.99**	6.14	1.00	**0.01**
7	908.11	1442.00	**0.99**	12.02	1.00	**<0.001**	1014.69	1876.00	**0.99**	5.01	1.00	**0.03**
8	906.03	1440.00	**0.99**	2.07	1.00	0.15	1014.10	1874.00	**0.99**	0.59	1.00	0.44
9	899.46	1438.00	**0.99**	6.57	1.00	**0.01**	1006.37	1872.00	**0.99**	7.73	1.00	**0.01**

Table A.3: Smoothing Results for C=1 to C=8*: Biology

Moments Preserved	NCEXTEND2						General					
	Overall Fit			Incremental Fit			Overall Fit			Incremental Fit		
	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*	G^2	*df*	*p*
1	1304.39	1454.00	**0.999**	.	.	.	709.27	1888.00	**0.999**	.	.	.
2	637.02	1452.00	**0.999**	667.37	1.00	**<0.001**	603.30	1886.00	**0.999**	105.97	1.00	**<0.001**
3	621.20	1450.00	**0.999**	15.83	1.00	**<0.001**	547.39	1884.00	**0.999**	55.92	1.00	**<0.001**
4	593.78	1448.00	**0.999**	27.42	1.00	**<0.001**	544.03	1882.00	**0.999**	3.36	1.00	0.07
5	577.56	1446.00	**0.999**	16.22	1.00	**<0.001**	522.68	1880.00	**0.999**	21.35	1.00	**<0.001**
6	575.14	1444.00	**0.999**	2.41	1.00	0.12	520.45	1878.00	**0.999**	2.23	1.00	0.14
7	557.60	1442.00	**0.999**	17.54	1.00	**<0.001**	514.92	1876.00	**0.999**	5.53	1.00	**0.02**
8	556.44	1440.00	**0.999**	1.16	1.00	0.28	512.71	1874.00	**0.999**	2.21	1.00	0.14

*

Table A.4: Unrounded EOG Equivalents and SEE for Grade 5 Science

NCEXTEND2 Number Correct	Unsmoothed		Initial Smooth		Final Smooth	
	EOG Eq.	SEE	EOG Eq.	SEE	EOG Eq.	SEE
0	-0.50	.	-0.50	.	0.40	.
1	-0.50	.	-0.50	0.85	1.21	.
2	-0.50	.	-0.49	0.85	1.21	.
3	-0.50	.	-0.48	0.90	1.21	.
4	-0.50	.	-0.46	0.90	1.23	.
5	-0.50	.	-0.43	0.90	1.43	.
6	-0.50	.	-0.38	1.21	2.72	.
7	-0.50	.	-0.28	1.56	4.22	.
8	-0.50	.	-0.11	1.79	4.22	.
9	-0.50	.	0.18	2.22	4.22	.
10	-0.50	.	0.65	2.48	4.22	.
11	-0.50	.	1.23	3.11	4.24	.
12	-0.50	.	2.11	3.24	4.49	.
13	-0.50	.	3.14	3.39	5.56	1.30
14	-0.50	.	4.33	3.69	7.56	2.31
15	-0.50	3.49	5.70	3.93	8.71	3.78
16	10.80	5.64	7.03	4.04	10.52	6.02
17	11.35	5.79	8.59	4.00	11.63	6.39
18	12.70	2.80	10.09	3.31	13.15	3.60
19	13.88	2.25	11.58	2.90	14.32	3.06
20	15.42	1.13	13.22	2.39	15.78	1.01
21	17.77	0.93	14.73	2.11	16.97	0.88
22	18.76	0.41	16.33	1.84	18.26	0.80
23	19.33	0.39	17.94	1.55	19.43	0.80
24	20.07	0.48	19.42	1.37	20.52	0.82
25	21.11	0.56	21.11	1.27	21.61	0.81
26	22.40	0.84	22.69	1.23	22.61	0.82
27	24.19	0.53	24.24	1.07	23.71	0.84
28	25.16	0.42	25.90	1.01	24.80	0.87
29	25.86	0.39	27.40	1.01	26.01	0.84
30	26.98	0.62	29.05	0.96	27.40	0.84
31	28.49	0.72	30.66	0.96	28.81	0.89
32	30.78	0.84	32.14	0.90	30.69	0.91
33	32.94	0.83	33.84	0.91	32.76	0.98
34	34.99	0.82	35.38	0.95	34.98	1.20

35	37.58	0.90	36.96	0.95	37.37	1.45
36	39.73	0.86	38.61	0.96	39.88	1.64
37	42.37	0.97	40.09	0.96	42.44	1.83
38	45.02	0.93	41.76	1.08	44.88	1.79
39	47.07	0.73	43.39	1.15	47.13	1.65
40	48.85	0.59	44.88	1.22	49.26	1.47
41	51.88	0.39	46.66	1.37	51.36	1.15
42	53.38	0.12	48.39	1.39	53.55	0.75
43	56.50	0.07	50.19	1.61	55.98	0.42
44	60.50	.	52.31	1.47	59.43	0.08
45	60.50	.	55.46	1.02	60.49	.

Table A.5: Unrounded EOG Equivalents and SEE for Grade 8 Science

NCEXTEND2 Number Correct	Unsmoothed		Initial Smooth		Final Smooth	
	EOG Eq.	SEE	EOG Eq.	SEE	EOG Eq.	SEE
0	-0.50	.	-0.49	.	6.94	1.74
1	-0.50	.	-0.44	.	7.64	1.78
2	-0.50	.	-0.37	1.02	8.02	1.78
3	-0.50	.	-0.25	1.36	8.56	2.63
4	-0.50	.	-0.04	1.70	8.91	3.58
5	11.56	5.88	0.27	1.84	9.56	5.13
6	11.62	5.94	0.70	2.33	10.09	5.80
7	11.62	5.94	1.26	2.48	10.80	5.03
8	11.75	1.75	1.95	2.71	11.62	2.97
9	11.99	0.49	2.78	2.85	12.51	1.44
10	12.36	0.92	3.72	2.98	13.48	1.30
11	13.50	1.15	4.75	3.09	14.37	1.01
12	13.50	1.18	5.86	3.03	14.50	0.95
13	13.50	1.18	7.02	2.93	14.56	0.96
14	13.78	1.20	8.25	2.89	14.64	0.96
15	14.31	1.21	9.49	2.31	14.74	0.97
16	14.83	1.19	10.75	2.23	14.88	0.99
17	15.34	1.14	12.03	2.00	15.11	1.04
18	15.95	1.12	13.32	1.82	15.40	1.10
19	16.51	1.07	14.65	1.74	15.79	1.09
20	16.96	0.94	15.92	1.68	16.30	1.09
21	17.74	0.80	17.26	1.55	16.90	1.08
22	18.42	0.78	18.59	1.54	17.70	1.09
23	18.68	0.72	19.86	1.52	18.53	1.15
24	19.28	0.67	21.23	1.40	19.57	1.14
25	20.59	0.80	22.53	1.31	20.64	1.14
26	21.79	0.67	23.86	1.28	21.81	1.15
27	22.90	0.71	25.21	1.24	23.08	1.19
28	24.10	0.96	26.46	1.20	24.31	1.20
29	25.71	0.80	27.87	1.17	25.67	1.16
30	26.42	0.55	29.17	1.20	26.89	1.08
31	27.49	0.95	30.49	1.17	28.30	1.04
32	29.95	1.35	31.87	1.12	29.50	1.05
33	32.30	1.07	33.10	1.17	30.98	1.06
34	33.31	0.81	34.52	1.23	32.31	1.13
35	34.23	0.92	35.84	1.27	33.87	1.33

NCEXTEND2 Number Correct	Unsmoothed		Initial Smooth		Final Smooth	
	EOG Eq.	SEE	EOG Eq.	SEE	EOG Eq.	SEE
36	35.81	1.01	37.11	1.32	35.59	1.58
37	36.54	1.27	38.53	1.47	37.50	1.67
38	37.84	1.63	39.78	1.56	39.71	1.76
39	41.50	2.21	41.17	1.72	42.21	1.82
40	45.53	1.62	42.54	2.53	44.73	1.79
41	47.25	1.34	43.77	3.16	47.06	1.80
42	49.83	0.91	45.29	3.30	49.08	2.34
43	60.50	.	46.71	3.05	50.45	2.21
44	60.50	.	48.10	2.45	52.13	1.53
45	60.50	.	49.98	1.77	52.78	0.86
46	60.50	.	52.51	0.70	54.47	.

Table A.6: Unrounded Equivalents and SEE for Biology EOC

NCEXTEND2 Number Correct	Unsmoothed		Initial Smooth		Final Smooth	
	EOC Eq.	SEE	EOC Eq.	SEE	EOC Eq.	SEE
0	-0.50	.	-0.38	.	-0.50	.
1	-0.50	.	-0.05	.	-0.49	.
2	-0.50	.	0.51	0.75	-0.37	.
3	-0.50	.	1.21	2.48	0.69	.
4	-0.50	.	2.15	3.07	2.45	.
5	-0.50	.	3.29	3.38	4.15	.
6	-0.50	.	4.46	4.35	5.94	1.22
7	-0.50	.	5.68	5.02	7.78	3.80
8	-0.50	.	6.92	5.46	9.64	6.33
9	14.77	7.64	8.19	5.89	11.53	7.26
10	15.32	5.13	9.46	6.22	13.41	6.31
11	16.41	1.61	10.71	6.70	15.32	5.83
12	17.82	1.94	11.93	6.81	17.27	5.80
13	18.50	2.07	13.18	6.74	19.73	4.31
14	18.50	2.07	14.41	6.23	21.19	3.31
15	18.50	2.07	15.63	5.87	21.68	3.18
16	18.50	2.07	16.84	4.91	21.99	3.15
17	18.50	2.07	18.05	4.61	22.26	2.44
18	18.76	2.11	19.27	3.97	22.53	2.44
19	19.21	2.09	20.47	3.75	22.78	2.40
20	21.33	2.25	21.68	2.88	23.05	2.41
21	22.49	2.20	22.88	2.63	23.32	2.41
22	23.78	2.19	24.06	2.59	23.64	2.36
23	24.61	2.01	25.29	2.34	23.93	2.38
24	24.88	2.03	26.50	2.37	24.33	2.41
25	25.35	2.12	27.66	2.19	24.70	2.44
26	27.21	1.95	28.90	2.09	25.18	2.42
27	28.18	1.69	30.07	2.01	25.66	2.33
28	28.71	1.34	31.26	1.92	26.29	2.31
29	28.98	1.05	32.50	1.95	26.93	2.33
30	29.39	0.94	33.65	1.83	27.80	2.38
31	30.03	0.93	34.86	1.85	28.66	2.36
32	30.84	1.25	36.09	1.86	29.94	2.37
33	31.75	1.73	37.21	1.75	31.31	2.51
34	32.25	1.83	38.46	1.71	32.93	2.47
35	34.39	1.79	39.67	1.77	35.03	2.65

36	35.90	2.82	40.77	2.09	37.33	3.04
37	40.50	3.54	42.06	2.50	39.75	3.30
38	43.78	3.09	43.26	2.74	42.18	3.32
39	44.33	2.44	44.37	3.11	44.63	3.65
40	45.56	0.80	45.69	3.60	46.92	3.52
41	48.00	1.46	46.91	3.62	48.91	3.53
42	60.50	.	48.05	3.21	50.52	3.07
43	60.50	.	49.45	2.20	52.25	2.07
44	60.50	.	50.88	1.28	53.64	1.40
45	60.50	.	52.49	1.16	54.93	1.17
46	60.50	.	54.91	0.54	56.53	0.69

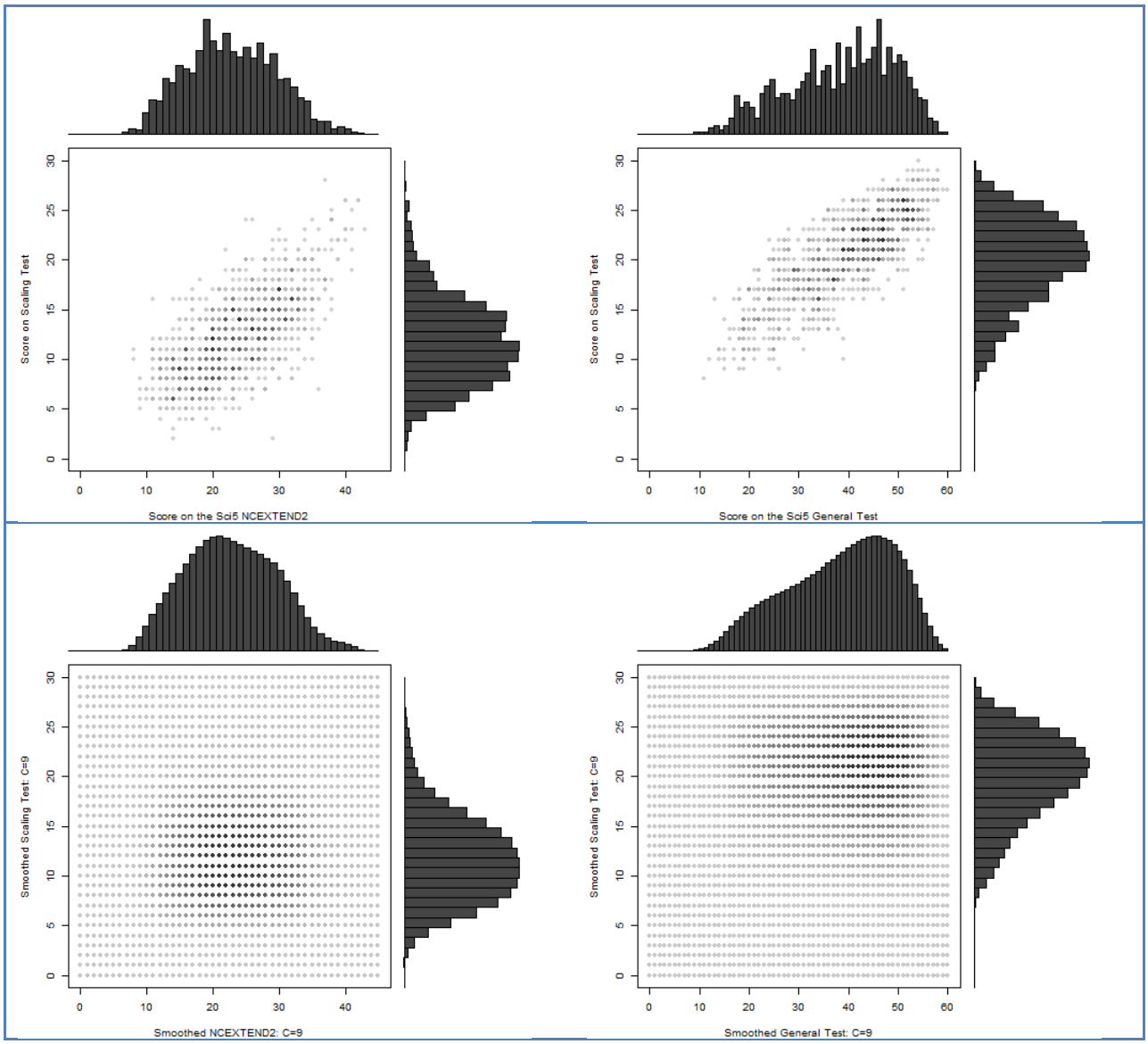

Figure A.1: Observed and Smoothed Score Distributions of Science Grade 5 NCEXTEND2, EOG, and Linking Tests

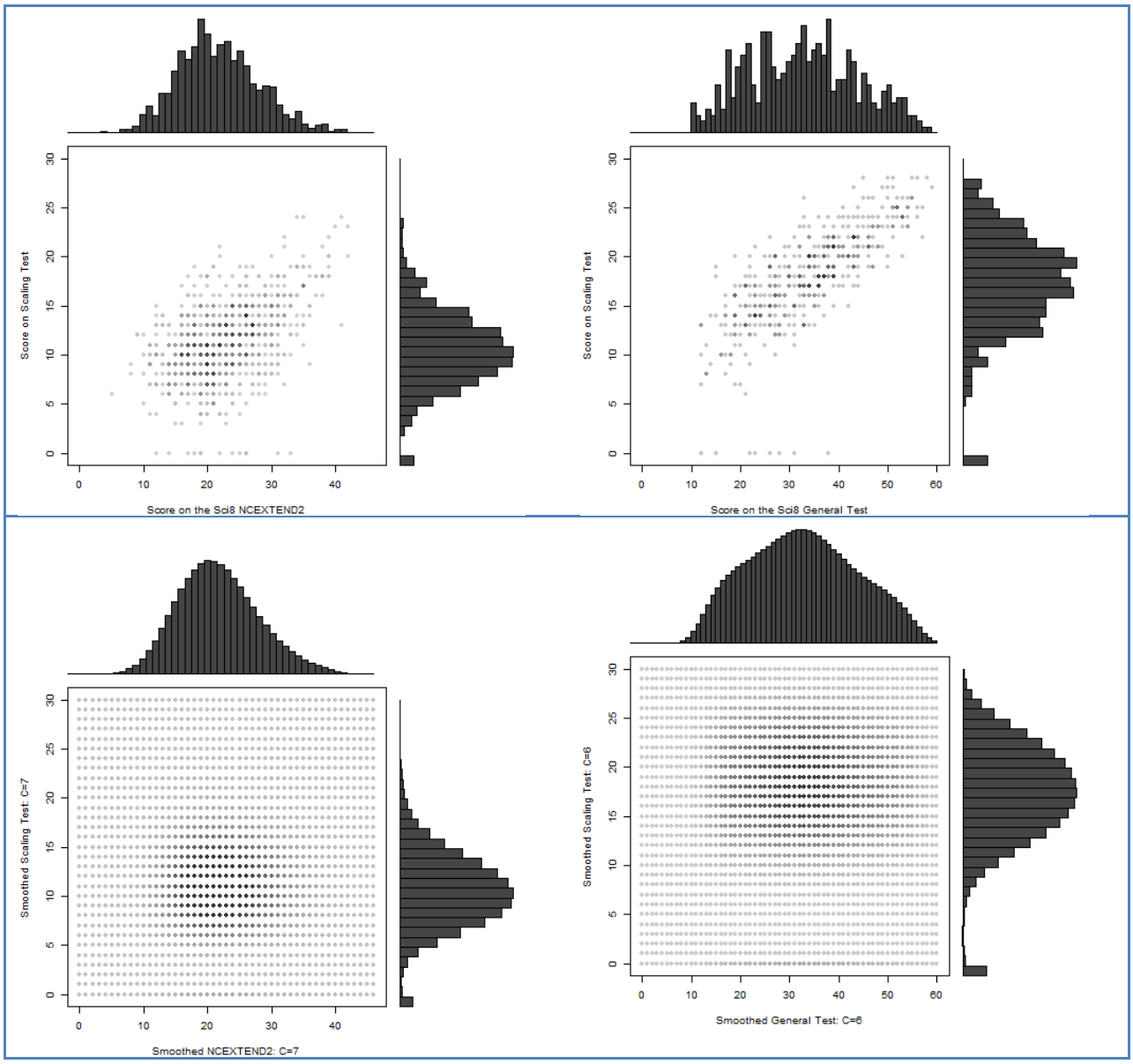

Figure A.2: Observed and Smoothed Score Distributions of Science Grade 8 NCEXTEND2, EOG, and Linking Tests

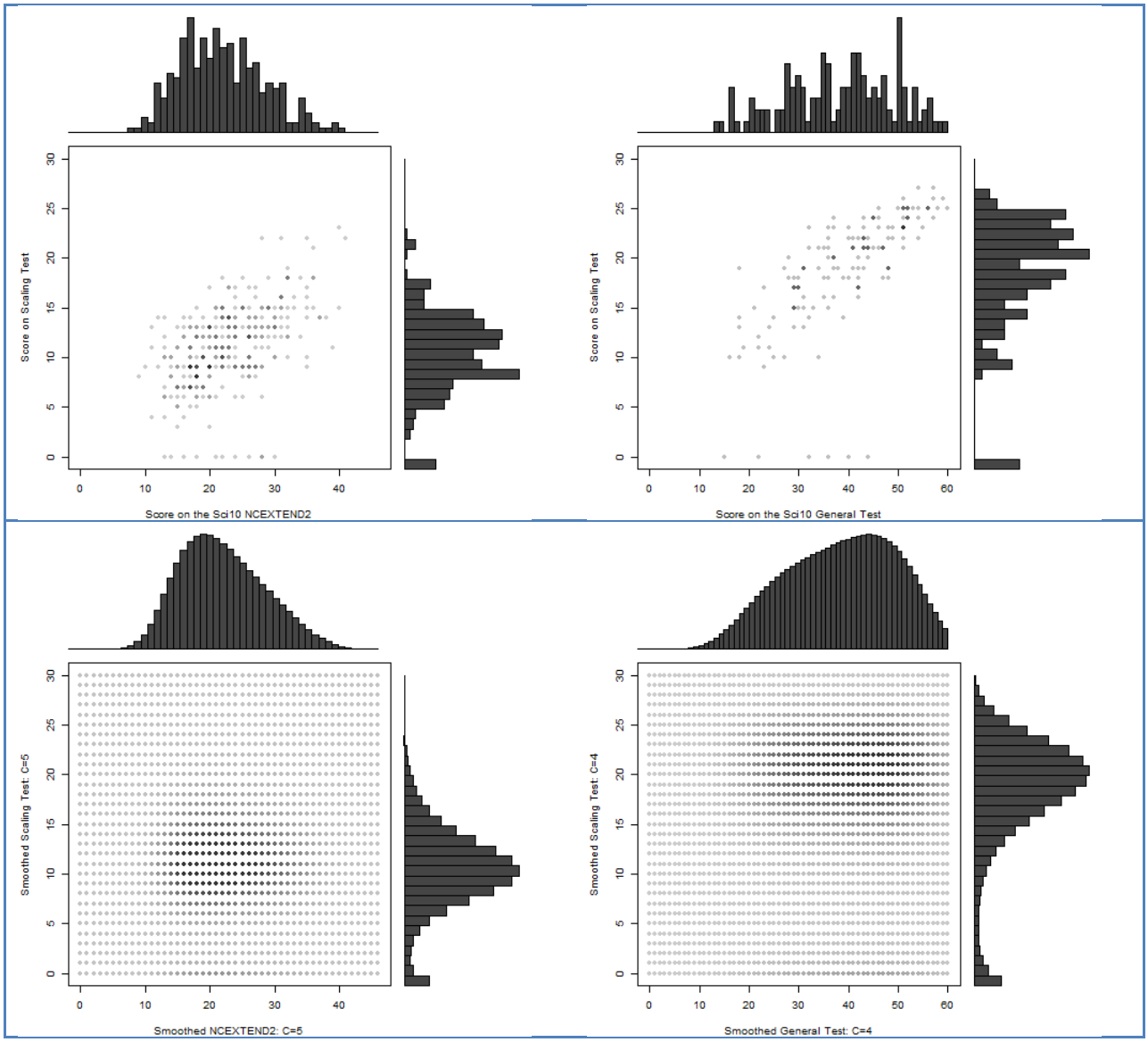

Figure A.3: Observed and Smoothed Score Distributions of Biology NCEXTEND2, EOC, and Linking Tests

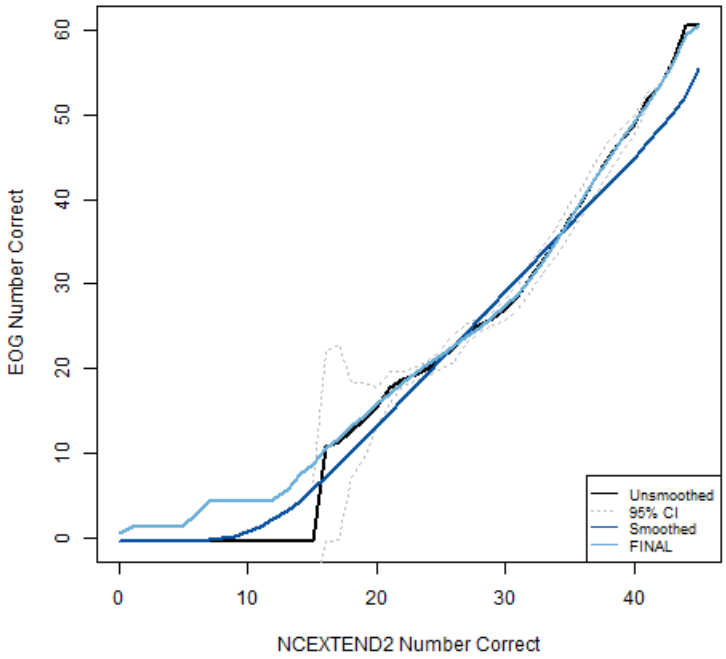

Figure A.4: Grade 5 Science: Unsmoothing and Smoothed Concordance Relationships

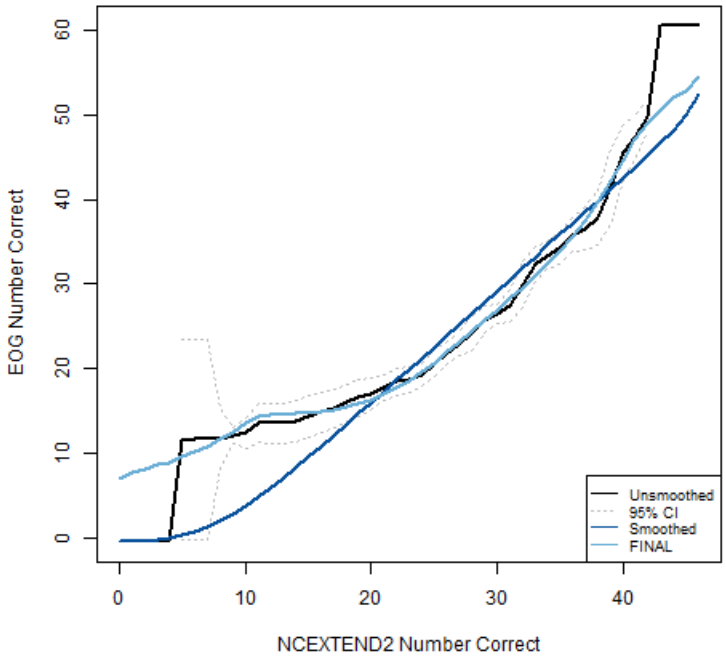

Figure A.5: Grade 8 Science: Unsmoothing and Smoothed Concordance Relationships

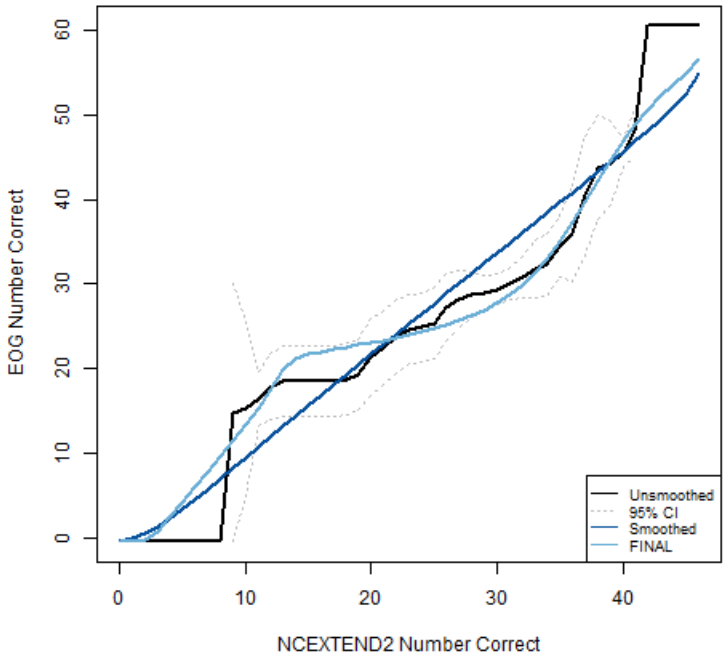

Figure A.6: Biology: Unsmoothing and Smoothed Concordance Relationships