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easyCBM® Slope Reliability: Letter Names, Word Reading Fluency, and Passage Reading Fluency

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Chalie Patarapichayatham

Daniel Anderson

P. Shawn Irvin

Akhito Kamata

Julie Alonzo

Gerald Tindal

University of Oregon

Behavioral Research and Teaching
University of Oregon • 175 Education
5262 University of Oregon • Eugene,
OR 97403-5262 Phone: 541-346-3535
• Fax: 541-346-5689
http://brt.uoregon.edu

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Abstract

Within a response to intervention (RTI) framework, students are administered multiple tests of equivalent difficulty. Changes in students' scores over time are then attributed to changes in learning. In the current study, we evaluated the reliability of score changes (i.e., slope) for the easyCBM® letter names, word reading fluency, and passage reading fluency measures. Data came from a sample of convenience and included students taking at least three tests of one measure type during one academic year (up to 38 weeks). Data were organized into bi-weekly segments and a growth model for two parallel processes was conducted, with "A" weeks (2A, 3A, 4A, 5A, 6A, 7A, 8A, and 9A) in one process and "B" weeks (2B, 3B, 4B, 5B, 6B, 7B, 8B, and 9B) in the other. A linear growth model was conducted in each process and the individual slopes were estimated within the growth modeling framework. Then, the reliability of the slope was estimated as the correlation between individual slopes from the two parallel processes with a correction by the Spearman-Brown formula.

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Perhaps the key component of response to intervention (RTI) is the ability to monitor and evaluate changes in student learning progressions. In the general RTI model, teachers administer screening measures to identify students in need of additional instructional attention. Once students are identified, an intervention is provided with the intent of increasing the rate at which the student learns the material. If the student responds to the intervention and the slope becomes markedly steeper, then the teacher has gained evidence that a particular intervention works well for that particular student. However, if the student does not respond to the intervention and progress is not made, then the teacher has gained evidence that the intervention is not effective for the student and a different intervention strategy should be explored. Thus learning gains within RTI are used to evaluate both the rate the individual student is learning *and* the effectiveness of a particular intervention strategy. Given the importance of these decisions, it is paramount that the set of measures used provide reliable estimates of the growth slope over time.

In this technical report, we provide evidence for the reliability of the slope for three easyCBM® reading measures: Letter Names, Word Reading Fluency, and Passage Reading Fluency. A parallel processing linear growth model via structural equation modeling was applied to extant data collected across the 2010-2011 school year.

Methods

In this section we describe the easyCBM® measures under investigation, the sample of students included in each analysis, and the model applied.

Measures

The easyCBM® reading measures were developed in 2006 specifically for use within an RTI framework. There are 20 alternate forms of each measure type, each designed to be of equivalent difficulty. Of the 20 measures available, three are designated for tri-annual benchmark screening (fall, winter, and spring), with the remaining 17 designated for monitoring the progress of students receiving an intervention. All assessments under investigation are fluency based. Students are given 60 seconds to complete as much of the form as possible (i.e., naming letters, reading words, or reading from a passage). Students' self-corrections are treated as correct responses while omissions are scored "missing". All forms were created to be as comparable as possible in terms of difficulty.

Letter names. For a full description of the development of the letter names measures, see Alonzo and Tindal (2007b). The letter names measures were administered in kindergarten and first grade to assess students' fluency in naming letters of the English alphabet, both in lower and upper case formats. During alternate form creation, each letter was treated as an item and a unidimensional Rasch model was applied to estimate item difficulties. Letters in their lower and upper case form were treated as separate items.

Word Reading Fluency. For a full description of the development of the word reading fluency measures, see (Alonzo & Tindal, 2007a). The word reading fluency measures were administered in kindergarten through third grade to assess students' fluency with common "sight words" and words following regular patterns of letter/sound correspondence in the English language. During alternate form creation, an item bank of words was created. Each word was treated as an item and a unidimensional Rasch model was applied to estimate item difficulties. Dolch lists were the used to choose grade-level appropriate words.

Passage Reading Fluency. For a full description of the development of the passage reading fluency measures, see (Alonzo & Tindal, 2007a). The passage reading fluency measures were administered in grades 1-8. Unlike the Letter Name and Word Reading Fluency measures, a Rasch model could not be used to scale the forms because there are no distinct "items". Rather, the passage reading fluency measure consists of a passage of approximately 250 words of grade-level appropriate text from which the student reads. Correlations and mean differences were used to obtain information on the relative difficulty of each passage.

Data Sources and Preparation

All data used in this study were collected from an extant database. The easyCBM® progress monitoring assessment system has several thousand users and the research reported here capitalized on the existing data from users of the system. The raw data file contained student scores for all progress monitoring assessments administered throughout the 2010-2011 school year. In other words, any student who had taken at least one easyCBM® assessment during the year and had data recorded into the online system were represented – totaling approximately 170,000 students per grade. The following steps were taken in cleaning the data file for the purpose of this study:

a) Delete students with fewer than than 3 observed scores.
b) Delete students with off-grade level testing (i.e., if the measure grade does not equal the students' grade).
c) Delete students who performed at the 50th percentile or better on their first progress monitoring measure.
d) Recode scores of 0 to missing data
e) Average students' scores that occurred within 1 week.

f) Collapse (average) weekly observations into bi-weekly segments.

Although there are certainly other steps that could have been taken in cleaning the data, we felt each of these steps were necessary. Students with less than three time points were deleted because their contribution in estimation of the overall rate of growth would be limited. This step in the process generally resulted in the greatest drop in the overall sample size, as many students were included with only one or two time points in the original data files. Data from students taking measures outside of their grade-level were also eliminated because we wanted to ensure the results would reflect students' from the grade in which the measures were designed. Additionally, because the purpose of easyCBM® progress monitoring measures is to track students who are falling behind, we eliminated data from all students scoring at or above the 50th percentile in their first progress monitoring measure. As Anderson, Lai, Alonzo, and Tindal (2011) showed, easyCBM® measures are designed to optimally measure students performing below expectations. The measures themselves are likely not as sensitive to the growth that students performing above the 50th percentile make. Students' with scores of 0 were recoded to missing because the score was unlikely representative of the students' true reading ability. For example, the test form may have been inappropriately administered, as the student was unable to access the scale. In this case, a score of 0 would not represent the 'absence' of reading ability but instead an inability to access the language in the test form administered.

Students with multiple measures administered within the same week had the scores averaged, resulting in a data file with one variable representing each week of the school year. Scores within a week were averaged primarily as control for measurement error. For example, if a student were administered two measures in one week and the student scored a 2 and 12, then a score of 7 would likely be more representative of the students' true ability than either the score

of 2 or 12. Finally, the weekly variables were collapsed into bi-weekly segments to reduce the sparseness of the data, which also increased the sample size within each time segment. Collapsing to bi-weekly segments also allowed more time to pass between time points so the changes in score would be more likely to be representative of students' learning.

Data Analysis

This study aimed to estimate the reliability of the slope for three easyCBM® measures. Under a structural equation modeling (SEM) framework, a growth model with two parallel growth processes was used. Essentially, two linear growth models were simultaneously modeled. The two parallel growth processes were established by splitting the available time segments into two groups. One group of time segments was used to form one linear growth process, and another group of time segments was used to form another linear growth process. For each linear growth process, the individual slopes of growth were estimated as factor scores of the latent slope factor. Then, the correlation between individual slopes from the two parallel growth processes was computed as an estimate of the reliability of the growth slope. The Spearman-Brown formula was then used to correct the correlation coefficient because each process had only half the available time represented.

The procedure was analogous to VanDerHeyden and Burns (2008). In order to estimate the reliability of a slope, they (1) split a series of longitudinal observations into two parallel series, (2) computed an OLS regression slope for each individual for each series, (3) computed the correlation of the individual slopes between the two parallel series, and (4) corrected the correlation by the Spearman-Brown formula. Our procedure was exactly the same as VanDerHyden and Burns' four-step procedure, with one exception. For step 2 VanDerHyden and Burns's derived a direct estimate of individual slopes based only on the observed measures of

each student. By contrast, our method used empirical Bayes estimates of individual slopes (e.g., Raudenbush & Bryk, 2002) that incorporated information about the estimated mean slope and the estimated variance of individual slopes from the entire sample data.

The bi-weekly segments were evenly split into two parallel processes in the following manner. The first bi-weekly segment (average of weeks 1 and 2) was labeled 1A and assigned to a group of time segments for one linear growth process (Process A). The second bi-weekly segment (average of weeks 3 and 4) was labeled 1B and assigned to a group of time segments for another linear growth process (Process B). Similarly, the third bi-weekly segment (average of weeks 5 and 6) was labeled 2A and assigned to Process A, while the fourth bi-weekly segment (average of weeks 7 and 8) was labeled 2B and assigned to Process B. This pattern continued for the entire available bi-weekly segments, totaling 20 time segments, 1A – 10B, across 38 weeks of the school year. However, in many grades there were zero or near-zero students represented in the first two time segments (1A and 1B) and the last two time segments (10A and 10B). Also, there were other time segments with very few observations for some of the data sets. As a part of data cleaning process, descriptive statistics for each time segment for each data set were examined, and time segments with zero or near-zero students represented were deleted from the data.

In each data set, the linear growth model for two parallel processes was fit. The first linear growth model (Process A) was fit with the "A" time segments (2A, 3A, 4A, 5A, 6A, 7A, 8A, and 9A), whereas the second linear growth model (Process B) was fit with the "B" time segments (2B, 3B, 4B, 5B, 6B, 7B, 8B, and 9B). For both growth processes, the time scores of the growth slope factor were fixed to 0, 1, 2, 3, 4, 5, 6, 7, and 8 to define a linear growth model with equal time intervals between time segments. The zero time score for the growth slope factor

at time segment one defines the intercept, initial status factors. On the other hand, the coefficients of the growth intercept factors were fixed at one as part of the regular growth model parameterization. The residual variances of the outcome variables (observed test scores) were estimated but fixed to be the same across time segments. Also, it was assumed that the residuals were not correlated. On the other hand, the growth slope factors were assumed to be correlated. The correlation between the two growth slope factors from the two growth processes, was interpreted as the reliability of the slope of the growth. All parameters were estimated with the M*plus* software, using the Maximum Likelihood estimator with robust standard error. Note that due to some problems emerging during model parameter estimation, further data cleaning was pursued for some of the data sets, resulting in deletion of more time segments. All deleted time segments are displayed in bold-faced font in Tables 3 - 15.

Results

The slope reliability estimates are displayed in Table 1. The total sample sizes for each analysis are displayed in Table 2 and ranged from 122 to 1,146 depending on the data set. The sample size, means, and standard deviations are reported for each time point for the letter names measures in Tables 3 – 4, word reading fluency in Tables 5 – 7, and passage reading fluency in Tables 8 – 13. Overall, the slope reliabilities were high, all above .8 across measures and grades. The standard errors of the estimated reliabilities ranged from .017 to .194 across measures and grades.

Discussion

This study capitalized on an extant database to explore the reliability of the slope for the easyCBM® letter names, word reading fluency, and passage reading fluency. Overall, the results indicated that the observed slope – the rate at which easyCBM® scores change – was quite

reliable. Coefficients were generally above .9 and were universally above .8. This study provides increased evidence that changes in the easyCBM® observed scores are stable for letter names, word reading fluency, and passage reading fluency.

References

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Table 1

Reliability coefficients

Grade	Letter Names	Word Reading	Passage Reading
K	.859	-	-
1	.753	.812	.711
2	-	.881	.869
3	-	.853	.805
4	-	-	.820
5	-	-	.841
6	-	-	.775
7	-	-	.805
8	-	-	.495

Note. Values represent Spearman-Brown corrected correlation coefficient between each half of the parallel process model.

Table 2

Sample size for each model

Grade	Letter Names	Word Reading	Passage Reading
K	504	-	-
1	210	937	810
2	-	665	385
3	-	122	966
4	-	-	1,020
5	-	-	1,146
6	-	-	411
7	-	-	393
8	-	-	287

Note. Values represent Spearman-Brown corrected correlation coefficient between each half of the parallel process model.

Table 3
Letter Names Descriptive Statistics: Grade K

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	20	1	11	4.60	3.119
1B	29	1	12	7.10	3.244
2A	116	1	15	6.54	3.681
2B	169	1	35	8.79	5.649
3A	145	1	37	10.24	7.079
3B	170	1	50	13.51	8.600
4A	254	1	51	15.59	10.135
4B	86	2	38	14.01	7.995
5A	140	1	48	20.84	11.191
5B	131	2	59	23.39	12.661
6A	155	2	47	19.79	10.576
6B	303	1	75	23.63	12.848
7A	244	2	60	25.81	11.684
7B	261	2	82	28.28	14.321
8A	129	1	61	27.41	11.521
8B	212	2	96	31.09	14.787
9A	167	2	66	28.10	11.237
9B	99	5	69	29.27	12.401
10A	68	5	56	31.14	11.726
10B	**0**				
Valid N (listwise)	0				

Table 4
Letter Names Descriptive Statistics: Grade 1

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**3**	**3**	**37**	**23.00**	**17.776**
1B	**31**	**6**	**40**	**27.74**	**8.869**
2A	56	1	44	28.07	9.691
2B	105	8	62	32.58	8.846
3A	95	3	60	33.62	10.396
3B	64	6	56	35.66	10.285
4A	88	7	93	37.64	11.059
4B	17	9	56	34.29	12.444
5A	33	8	93	41.73	14.481
5B	64	3	75	43.81	11.863
6A	32	26	70	44.53	10.770
6B	65	9	81	45.14	11.849
7A	56	8	75	47.06	13.447
7B	65	14	87	48.73	14.789
8A	46	18	68	49.48	10.994
8B	38	10	87	48.78	17.435
9A	45	28	98	53.01	16.205
9B	18	2	75	50.33	17.852
10A	26	26	78	57.35	12.270
10B	**0**				
Valid N (listwise)	0				

Table 5
Word Reading Fluency Descriptive Statistics: Grade 1

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**19**	**1**	**8**	**2.79**	**2.123**
1B	**68**	**1**	**8**	**3.87**	**1.939**
2A	193	1	11	4.82	2.336
2B	263	1	19	6.26	2.991
3A	302	1	25	6.88	3.953
3B	226	1	19	8.04	3.588
4A	382	1	21	9.97	4.491
4B	87	1	26	12.57	5.098
5A	119	1	24	10.50	4.627
5B	252	1	46	13.59	6.799
6A	327	2	42	13.26	5.761
6B	485	1	36	13.82	5.961
7A	501	1	58	16.43	8.098
7B	445	3	61	18.23	8.359
8A	337	1	53	18.46	9.120
8B	438	1	63	20.11	9.019
9A	486	3	59	21.29	9.990
9B	395	2	68	23.52	11.607
10A	152	5	64	26.05	11.651
10B	**0**				
Valid N (listwise)	0				

Table 6
Word Reading Fluency Descriptive Statistics: Grade 2

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**3**	**7**	**25**	**18.67**	**10.116**
1B	**119**	**4**	**37**	**17.97**	**7.829**
2A	221	1	39	16.29	8.028
2B	346	1	56	19.24	9.024
3A	300	1	53	21.36	9.431
3B	315	3	116	22.50	11.155
4A	299	2	48	22.90	10.172
4B	130	3	55	23.72	11.172
5A	161	4	61	25.93	11.175
5B	191	4	56	28.65	11.471
6A	205	4	60	29.39	11.781
6B	354	3	64	29.74	12.478
7A	317	3	69	33.25	13.697
7B	275	3	66	31.84	13.523
8A	180	5	68	32.98	13.586
8B	259	4	67	35.13	13.398
9A	291	6	71	35.71	14.153
9B	193	8	78	38.59	14.657
10A	79	4	71	38.31	18.618
10B	**0**				
Valid N (listwise)	0				

Table 7
Word Reading Fluency Descriptive Statistics: Grade 3

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**1**	**9**	**9**	**9.00**	**.**
1B	**10**	**7**	**17**	**13.40**	**4.300**
2A	46	4	25	15.52	6.221
2B	67	2	38	16.97	7.448
3A	52	5	38	16.40	8.059
3B	21	10	40	21.17	7.506
4A	**60**	**6**	**36**	**19.95**	**7.597**
4B	**21**	**5**	**32**	**17.38**	**9.030**
5A	10	9	35	21.10	8.399
5B	21	6	33	18.81	6.772
6A	22	9	41	24.41	10.617
6B	50	8	39	23.98	8.241
7A	33	4	40	22.92	9.715
7B	45	5	50	25.37	10.412
8A	27	5	76	32.41	14.058
8B	28	11	46	26.87	10.584
9A	58	7	53	28.48	11.622
9B	22	14	46	32.55	9.679
10A	17	14	50	31.75	10.793
10B	**0**				
Valid N (listwise)	0				

Table 8
Passage Reading Fluency Descriptive Statistics: Grade 1

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**0**				
1B	**1**	**2**	**2**	**2.00**	**.**
2A	16	1	7	4.31	2.213
2B	49	1	22	5.12	4.246
3A	41	1	26	4.98	4.156
3B	38	1	17	6.00	3.817
4A	124	1	40	8.37	5.510
4B	60	1	31	12.76	6.452
5A	86	1	35	10.80	6.581
5B	184	1	47	12.14	6.947
6A	277	1	58	13.97	7.349
6B	438	2	45	15.53	7.924
7A	505	1	68	19.11	10.247
7B	495	1	67	19.53	10.532
8A	315	1	69	21.82	12.991
8B	495	2	64	24.45	12.437
9A	547	1	79	26.17	15.366
9B	380	1	74	28.80	14.675
10A	191	2	92	33.95	19.907
10B	**0**				
Valid N (listwise)	0				

Table 9
Passage Reading Fluency Descriptive Statistics: Grade 2

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**20**	**5**	**25**	**15.13**	**7.095**
1B	**76**	**2**	**33**	**16.24**	**5.866**
2A	188	2	68	17.92	9.289
2B	231	2	107	22.09	11.055
3A	192	3	56	24.34	11.508
3B	156	2	52	26.88	11.840
4A	223	2	64	27.52	12.182
4B	77	3	60	27.91	14.305
5A	78	4	109	34.53	16.921
5B	114	1	106	32.75	16.851
6A	154	5	85	36.37	14.848
6B	244	2	95	38.15	18.366
7A	218	4	116	42.19	17.070
7B	199	3	102	43.16	19.132
8A	172	5	114	43.65	19.426
8B	198	1	100	46.25	19.675
9A	211	1	101	44.94	19.092
9B	128	2	121	51.75	22.460
10A	69	9	108	56.57	25.595
10B	0				
Valid N (listwise)	0				

Table 10
Passage Reading Fluency Descriptive Statistics: Grade 3

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	67	11	83	56.47	18.686
1B	178	1	91	55.60	18.804
2A	345	7	111	59.73	18.196
2B	599	2	133	62.37	20.324
3A	421	8	123	66.87	20.550
3B	430	11	119	70.43	19.932
4A	513	13	127	70.41	22.567
4B	216	7	114	73.54	22.218
5A	192	4	121	72.73	21.610
5B	270	10	132	75.44	21.963
6A	356	4	142	79.81	21.891
6B	620	11	216	81.83	22.258
7A	480	9	146	80.60	22.209
7B	559	14	137	82.89	22.475
8A	377	13	148	84.76	22.452
8B	469	8	162	83.86	23.098
9A	541	15	165	85.83	23.066
9B	343	9	164	88.37	21.825
10A	159	8	130	86.70	23.729
10B	**0**				
Valid N (listwise)	0				

Table 11
Passage Reading Fluency Descriptive Statistics: Grade 4

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	69	19	105	84.43	18.920
1B	144	18	116	79.26	17.920
2A	376	6	137	84.40	20.936
2B	469	9	131	84.66	19.716
3A	503	15	146	89.60	20.592
3B	393	24	154	90.90	19.570
4A	526	3	141	88.52	24.672
4B	192	25	139	95.81	20.114
5A	206	28	146	97.46	21.059
5B	303	3	144	95.75	22.513
6A	408	22	150	98.43	19.995
6B	566	11	167	95.61	22.568
7A	572	1	177	103.87	21.589
7B	542	7	153	101.14	23.824
8A	288	42	172	102.30	22.041
8B	470	12	179	105.82	22.808
9A	482	2	188	105.76	23.781
9B	364	36	152	109.97	20.607
10A	185	50	180	106.93	23.704
10B	**0**				
Valid N (listwise)	0				

Table 12
Passage Reading Fluency Descriptive Statistics: Grade 5

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	36	39	147	105.79	23.321
1B	174	9	160	105.86	24.709
2A	427	5	193	107.04	25.446
2B	533	14	198	108.46	28.131
3A	602	13	211	113.55	27.905
3B	447	15	215	117.47	27.610
4A	543	16	205	119.96	28.706
4B	255	12	175	116.08	28.179
5A	244	29	186	119.58	26.595
5B	380	51	190	120.86	26.571
6A	367	41	203	122.00	25.512
6B	494	20	203	120.45	28.536
7A	604	11	220	124.66	28.630
7B	482	41	194	122.30	26.689
8A	297	44	184	121.77	25.861
8B	461	22	214	126.40	29.502
9A	521	2	201	126.97	27.834
9B	296	1	217	126.52	28.365
10A	174	27	223	130.00	29.236
10B	**0**				
Valid N (listwise)	0				

Table 13
Passage Reading Fluency Descriptive Statistics: Grade 6

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**32**	**83**	**131**	**111.20**	**12.814**
1B	**42**	**33**	**149**	**111.83**	**23.613**
2A	141	24	160	100.72	26.115
2B	150	18	150	100.65	27.767
3A	143	7	162	100.40	29.318
3B	116	31	170	105.65	27.873
4A	129	29	251	113.52	30.587
4B	93	35	173	100.72	29.636
5A	121	24	170	107.07	28.725
5B	126	13	159	103.90	29.776
6A	80	44	186	109.06	25.182
6B	121	21	190	111.83	31.379
7A	134	38	207	115.61	28.271
7B	111	6	186	118.39	32.304
8A	165	42	249	115.40	29.285
8B	158	36	210	115.74	30.303
9A	145	24	215	122.05	34.865
9B	**51**	**61**	**173**	**123.67**	**25.428**
10A	**35**	**24**	**185**	**117.06**	**43.986**
10B	**0**				
Valid N (listwise)	0				

Table 14
Passage Reading Fluency Descriptive Statistics: Grade 7

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	51	44	150	112.82	24.775
1B	43	85	175	132.47	20.536
2A	109	36	170	112.83	26.431
2B	175	30	175	116.14	27.849
3A	118	23	187	120.32	26.762
3B	81	28	203	121.96	27.377
4A	**192**	**4**	**185**	**108.18**	**34.597**
4B	**73**	**40**	**178**	**107.96**	**30.366**
5A	**86**	**44**	**177**	**108.37**	**29.759**
5B	106	16	170	115.05	31.199
6A	141	22	192	128.26	30.802
6B	140	19	183	114.52	28.089
7A	128	45	175	119.52	27.167
7B	91	34	189	116.29	31.463
8A	90	40	186	128.24	26.770
8B	107	63	185	125.76	27.152
9A	149	23	196	123.50	33.089
9B	67	24	180	110.44	31.384
10A	**14**	**60**	**154**	**110.29**	**30.603**
10B	**0**				
Valid N (listwise)	0				

Table 15
Passage Reading Fluency Descriptive Statistics: Grade 8

Time Point	N	Minimum	Maximum	Mean	Std. Deviation
1A	**63**	**27**	**164**	**110.27**	**29.750**
1B	**59**	**32**	**164**	**112.75**	**29.061**
2A	101	2	166	110.13	33.963
2B	129	38	185	113.76	32.149
3A	77	30	199	116.07	33.171
3B	83	44	170	121.17	27.604
4A	106	23	176	122.83	28.678
4B	24	49	164	120.00	26.459
5A	29	63	178	124.10	29.873
5B	47	62	195	134.73	27.731
6A	96	50	209	134.13	30.603
6B	108	78	177	130.73	20.602
7A	83	43	196	134.21	25.094
7B	79	31	180	121.50	29.533
8A	46	57	178	127.38	25.972
8B	57	57	190	122.55	27.817
9A	**117**	**40**	**208**	**135.35**	**28.333**
9B	**44**	**24**	**205**	**126.70**	**36.000**
10A	**6**	**103**	**145**	**128.50**	**16.909**
10B	**0**				
Valid N (listwise)	0				