



TECHNICAL REPORT #18:

Characteristics of Reading Aloud, Word Identification, and
Maze Selection as Growth Measures: Identifying the
Number of Data Points Needed to Obtain Consistency in
Slopes

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Note: Data set and data collection procedures are the same for Technical Reports #17, #18, #19, and #20.

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The purpose of this study was to investigate technical features of slopes from reading aloud, word identification, and maze selection measures used to monitor reading progress of students in Grades 1 through 5 and Grade 9 across 12 weeks. Specific research questions included: (1) At each grade level, which measures produce slopes that are statistically significantly greater than zero? (2) At each grade level, how often must progress monitoring measures in reading be administered to obtain reliable slopes?

Method

The participants, setting, CBM measures, and procedures are the same as found in Technical Reports #17, #18, #19, and #20. See Technical Report #17 for complete details on participants, setting, CBM measures, and procedures.

Data Analyses

For all analyses, students in Grade 2 ($n = 10$) were included in the same group as students in Grade 3 and students in Grade 4 ($n = 6$) were included in the same group as students in Grade 5 group. This decision was made based on the fact that there were two classrooms that combined grade levels (one Grade 2/3 split and one Grade 4/5 split) and the classroom teachers reported that there was no differentiation in reading instruction based on grade level within the classroom. Students in Grade 2 were receiving the same reading instruction as students in Grade 3 and students in Grade 4 were receiving the same reading instruction as students in Grade 5.

Group level analyses. To calculate growth rate and intercept, a latent growth model (LGM), which is based on the group level, was employed using the AMOS 4.0 program. Missing data were handled using the full-information maximum likelihood (FIML) statistical method in the AMOS program. The AMOS program changes from its default algorithm (moment-based

| | | | | | | | | | | | | |
|------|-------|------|-------|--------|------|-------|--------|------|-------|---------|------|-------|
| 1-12 | 1.19 | .000 | .190 | .835 | .000 | .140 | .922 | .000 | .178 | -1.311 | .000 | .186 |
| 1-6 | 1.618 | .000 | 0.372 | -0.688 | .067 | 0.368 | 3.551 | .000 | 0.430 | 1.465 | .010 | 0.563 |
| 7-12 | 3.210 | .000 | 0.376 | 3.861 | .000 | 0.401 | 2.683 | .000 | 0.532 | -2.295 | .000 | 0.465 |
| ODD | 0.921 | .000 | 0.188 | .664 | .000 | 0.190 | 2.083 | .000 | 0.287 | -1.079 | .000 | 0.250 |
| EVEN | 1.117 | .000 | 0.228 | .885 | .000 | 0.172 | -1.155 | .434 | 0.196 | .371 | .000 | 0.072 |
| 1-2 | 8.216 | .373 | 0.408 | 2.240 | .755 | 7.177 | 5.459 | .365 | 5.989 | 12.108 | .037 | 5.716 |
| 1-3 | 1.500 | .046 | 0.733 | -6.380 | .000 | 1.065 | 1.465 | .233 | 1.207 | 13.670 | .000 | 2.101 |
| 1-4 | 3.354 | .000 | 0.510 | -3.795 | .000 | 0.622 | 4.764 | .000 | 0.811 | -4.600 | .000 | 0.943 |
| 1-5 | 0.647 | .161 | 0.456 | -1.539 | .002 | 0.460 | 3.340 | .000 | 0.524 | -0.1743 | .815 | 0.744 |

As shown in Table 2, the estimated average slope for maze was statistically significantly different from zero for all grades for the following data collection schedules: Weeks 1-12, Weeks 1-6, weeks 7-12, every other even week, every other odd week, and weeks 1-5. In addition, the estimated average slope for maze was statistically significantly different from zero for the following grades and data collection schedules (estimated average slopes that were *not* statistically significantly different from zero are shaded in gray): Weeks 1-2 (Grade 4/5 & 9), weeks 1-3 (Grades 1, 4/5, & 9), and weeks 1-4 (Grades 1, 4/5, & 9).

Table 2. Slope Estimates for Maze Selection (Shaded cells = NOT significant)

| Weeks | Grade 1 | | | Grade 2/3 | | | Grade 4/5 | | | Grade 9 | | |
|-------|----------|------|-------|-----------|------|-------|-----------|------|-------|----------|------|-------|
| | Estimate | Sig. | S.E. | Estimate | Sig. | S.E. | Estimate | Sig. | S.E. | Estimate | Sig. | S.E. |
| 1-12 | .369 | .000 | .060 | .555 | .000 | .042 | .709 | .000 | .057 | .358 | .000 | .047 |
| 1-6 | .876 | .000 | 0.135 | .741 | .000 | 0.115 | 1.302 | .000 | 0.102 | 1.093 | .000 | 0.135 |
| 7-12 | .332 | .010 | 0.123 | .853 | .000 | 0.083 | .927 | .000 | 0.109 | .403 | .016 | 0.166 |
| ODD | .369 | .000 | 0.065 | .554 | .000 | 0.056 | .856 | .000 | 0.065 | .777 | .001 | 0.229 |

| | | | | | | | | | | | | |
|------|-------|------|-------|-------|------|-------|-------|------|-------|-------|------|-------|
| EVEN | .359 | .000 | 0.070 | .612 | .000 | 0.041 | .518 | .000 | 0.061 | .371 | .000 | 0.072 |
| 1-2 | 1.200 | .219 | .971 | -.039 | .971 | 1.077 | 4.658 | .000 | 1.132 | 4.073 | .001 | 1.170 |
| 1-3 | .650 | .008 | 0.234 | .019 | .950 | 0.310 | 1.868 | .000 | 0.291 | 3.380 | .000 | 0.385 |
| 1-4 | .832 | .000 | 0.177 | -.039 | .842 | 0.195 | 2.347 | .000 | 0.167 | 1.441 | .000 | 0.281 |
| 1-5 | .729 | .000 | 0.153 | .862 | .000 | 0.172 | 1.542 | .000 | 0.145 | 1.345 | .000 | 0.178 |

As shown in Table 3, the estimated average slope for word identification for Grade 1 was significantly different from zero for all data collection schedules except weeks 1-2.

Table 3. Slope Estimates for Word Identification (Shaded cells = NOT significant)

| Weeks | Grade 1 | | |
|-------|----------|------|------|
| | Estimate | Sig | S.E |
| 1-12 | 1.760 | .000 | .49 |
| 1-6 | 2.060 | .000 | 1.05 |
| 7-12 | 2.893 | .000 | 1.07 |
| ODD | 1.759 | .000 | .52 |
| EVEN | 1.727 | .000 | .53 |
| 1-2 | 2.484 | .659 | 5.62 |
| 1-3 | 1.657 | .013 | 2.91 |
| 1-4 | 1.686 | .001 | 1.92 |
| 1-5 | 1.914 | .000 | 1.93 |

Group Level: Correlating Slopes (Wks. 1-3, Wks. 1-4 , Wks 1-5, etc) with Overall Slope (Wks. 1-12)

In order to answer the research question about how often progress monitoring measures must be administered to obtain reliable slopes, correlation coefficients between the slope of the aggregate scores across consecutive weeks (Wks. 1-3, Wks 1-4 etc) and the overall slope (Wks 1-12) were calculated for each grade level. Table 4 shows that, overall, correlation coefficients between the slope of the aggregate scores across consecutive weeks (Wks. 1-3, Wks 1-4 etc) and overall slope (Wks 1-12) for reading aloud at each grade level ranged from .37 to .95 for Grade 1, .20 to .85 for Grade 2/3, -.07 to .94 for Grade 4/5, and .06 to .94 for Grade 9. The correlations increased as the number of data points used to create the slope increased. This pattern was similar for all grade levels.

Table 4. Correlating Slopes (Wks. 1-3, Wks. 1-4 , Wks 1-5, etc) with Overall Slope (Wks. 1-12) for Reading Aloud

| Overall Slope | Wks 1-3 | Wks 1-4 | Wks 1-5 | Wks 1-6 | Wks 1-7 | Wks 1-8 | Wks 1-9 | Wks 1-10 | Wks 1-11 |
|------------------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
| Grade 1 | .370 | .347 | .476 | .536 | .627 | .780 | .745 | .857 | .947 |
| Grade 2/3 | .197 | .236 | .160 | .379 | .428 | .514 | .619 | .730 | .848 |
| Grade 4/5 | -.074 | .150 | .055 | .284 | .489 | .513 | .637 | .786 | .942 |
| Grade 9 | .056 | .168 | .139 | .437 | .573 | .599 | .675 | .847 | .935 |

Table 5 shows the correlations between the slope of aggregate scores across consecutive weeks and the overall slope from week 1 to week 12 for maze selection. Overall, the correlation coefficients between each slope (Wks. 1-3, Wks 1-4 etc) and the overall slope (Wks 1-12) for maze selection ranged from .19 to .95 for Grade 1, .23 to .95 for Grade 2/3, .40 to .94 for Grade 4/5, and .05 to

.88 for Grade 9. Similar to the results for reading aloud, the correlations at each grade level increased as the number of data points used to create the slope increased.

Table 5. Correlating Slopes (Wks. 1-3, Wks. 1-4 , Wks 1-5, etc) with Overall Slope (Wks. 1-12) for Maze Selection

| Overall Slope | Wks 1-3 | Wks 1-4 | Wks 1-5 | Wks 1-6 | Wks 1-7 | Wks 1-8 | Wks 1-9 | Wks 1-10 | Wks 1-11 |
|------------------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
| Grade 1 | .190 | .222 | .455 | .573 | .695 | .715 | .771 | .839 | .954 |
| Grade 2/3 | .232 | .148 | .242 | .489 | .646 | .726 | .863 | .894 | .951 |
| Grade 4/5 | .404 | .315 | -.103 | .273 | .463 | .602 | .711 | .839 | .943 |
| Grade 9 | .052 | -.016 | .196 | .303 | .309 | .439 | .552 | .835 | .883 |

Table 6 shows the correlations between the slope of aggregate scores across consecutive weeks and the overall slope from week 1 to week 12 for word identification. Overall, the correlation coefficients between each slope (Wks. 1-3, Wks 1-4 etc) and the overall slope (Wks 1-12) for word identification ranged from .22 to .96 for students in Grade 1, with the pattern of correlation coefficients increasing with an increase in the number of data points used to create the slope.

Table 6. Correlating Slopes (Wks. 1-3, Wks. 1-4 , Wks 1-5, etc) with Overall Slope (Wks. 1-12) for Word ID

| Overall Slope | Wks 1-3 | Wks 1-4 | Wks 1-5 | Wks 1-6 | Wks 1-7 | Wks 1-8 | Wks 1-9 | Wks 1-10 | Wks 1-11 |
|----------------|---------|---------|---------|---------|---------|---------|---------|----------|----------|
| Grade 1 | .22 | .22 | .26 | .44 | .59 | .68 | .79 | .84 | .96 |

Individual Level: Testing the Difference between Standard Error of Slope (SEb) for 2-week, 3-week, etc. Slopes

Table 7 indicates the SEb of slopes for reading aloud. Mean scores of SEb based on each student decreased as the number of data points increased. In addition, mean scores of SEb increased as grade level increased. Regardless of grade level and the number of data points included, all SEb were significantly different from zero.

Table 7. SEb of aggregate scores (Wks. 1-3, Wks 1-4, Wks, 1-5 etc) for reading aloud

| Weeks | Grade 1 | | | | | Grade 2/3 | | | | | Grade 4/5 | | | | | Grade 9 | | | | |
|-------------|---------|------|------|------|------|-----------|------|------|------|------|-----------|------|------|-------|------|---------|------|------|-------|------|
| | Slope | Mean | S.D | t | sig | Slope | Mean | S.D | t | Sig | Slope | Mean | S.D | t | sig | Slope | Mean | S.D | t | Sig |
| 1-3 | 1.52 | 5.17 | 4.27 | 8.74 | .000 | -6.32 | 6.80 | 4.84 | 9.93 | .000 | 1.43 | 5.21 | 4.43 | 7.14 | .000 | -4.45 | - | - | - | - |
| 1-4 | 3.37 | 3.57 | 1.89 | 13.5 | .000 | -3.67 | 4.76 | 2.26 | 14.8 | .000 | 4.70 | 4.63 | 2.54 | 11.08 | .000 | -5.08 | 6.16 | 3.96 | 9.82 | .000 |
| 1-5 | .65 | 2.89 | 1.09 | 18.9 | .000 | -1.51 | 3.47 | 1.23 | 19.9 | .000 | 3.29 | 3.37 | 1.61 | 12.90 | .000 | -.04 | 4.74 | 2.47 | 13.28 | .000 |
| 1-6 | 1.60 | 2.19 | .964 | 16.4 | .000 | -.68 | 2.61 | 0.72 | 25.7 | .000 | 3.53 | 2.66 | 1.06 | 15.40 | .000 | 1.86 | 3.48 | 1.61 | 15.15 | .000 |
| 1-7 | 1.05 | 1.67 | .714 | 16.9 | .000 | -1.10 | 2.02 | 0.51 | 28.1 | .000 | 1.74 | 2.39 | 0.79 | 18.60 | .000 | .40 | 2.74 | 1.12 | 17.32 | .000 |
| 1-8 | .84 | 1.35 | .605 | 16.1 | .000 | -.87 | 1.61 | 0.40 | 28.7 | .000 | .41 | 2.06 | 0.64 | 19.78 | .000 | .18 | 2.13 | .78 | 19.26 | .000 |
| 1-9 | .23 | 1.18 | .543 | 15.7 | .000 | -.60 | 1.35 | 0.31 | 31.2 | .000 | 1.42 | 1.79 | 0.53 | 20.54 | .000 | -.47 | 1.77 | .54 | 23.00 | .000 |
| 1-10 | .70 | 1.02 | .512 | 14.3 | .000 | .12 | 1.22 | 0.31 | 27.4 | .000 | .42 | 1.61 | 0.48 | 20.63 | .000 | .18 | 1.54 | .44 | 24.59 | .000 |
| 1-11 | .78 | .892 | .458 | 14.0 | .000 | .54 | 1.07 | 0.27 | 28.3 | .000 | .73 | 1.38 | 0.39 | 21.85 | .000 | -.21 | 1.32 | .37 | 25.22 | .000 |
| 1-12 | 1.22 | .815 | .399 | 14.7 | .000 | .82 | .96 | 0.23 | 30.0 | .000 | .92 | 1.19 | 0.33 | 22.14 | .000 | -.94 | 1.20 | .30 | 28.00 | .000 |

Table 8 shows the SEb of slopes for maze selection. According to Table 7, mean scores of the SEb based on each student decreased as the number of data points increased. In addition, the mean scores of the SEb increased as grade level increased. Regardless of grade level and the number of data points, all of SEb for maze were significantly different from zero.

Table 8. SEb of aggregate scores (Wks. 1-3, Wks 1-4, Wks, 1-5 etc) for maze

| Weeks | Grade 1 | | | | | Grade 2/3 | | | | | Grade 4/5 | | | | | Grade 9 | | | | |
|-------------|---------|------|-----|-------|------|-----------|------|-----|-------|------|-----------|-------|------|-------|------|---------|-------|------|-------|------|
| | Slope | Mean | S.D | t | Sig | Slope | Mean | S.D | t | Sig | Slope | Mean | S.D | t | Sig | Slope | Mean | S.D | t | Sig |
| 1-3 | .67 | .708 | .49 | 10.04 | .000 | -.07 | .920 | .59 | 11.11 | .000 | 1.87 | 1.793 | 1.05 | 10.47 | .000 | 3.50 | 1.686 | 1.48 | 7.01 | .000 |
| 1-4 | .76 | .565 | .33 | 11.89 | .000 | -.10 | .804 | .45 | 12.54 | .000 | 2.33 | 1.094 | 0.55 | 12.20 | .000 | 1.47 | 1.577 | 0.93 | 11.28 | .000 |
| 1-5 | .68 | .448 | .24 | 12.96 | .000 | .74 | .635 | .36 | 12.33 | .000 | 1.51 | 0.912 | 0.35 | 15.86 | .000 | 1.44 | 1.091 | 0.53 | 14.21 | .000 |
| 1-6 | .83 | .382 | .18 | 14.51 | .000 | .65 | .529 | .26 | 14.38 | .000 | 1.29 | 0.742 | 0.28 | 15.93 | .000 | 1.01 | 0.834 | 0.36 | 15.69 | .000 |
| 1-7 | .65 | .317 | .15 | 14.16 | .000 | .56 | .427 | .20 | 15.10 | .000 | 1.06 | 0.575 | 0.19 | 18.11 | .000 | .65 | 0.678 | 0.24 | 19.58 | .000 |
| 1-8 | .54 | .277 | .13 | 14.58 | .000 | .45 | .357 | .14 | 17.15 | .000 | .84 | 0.493 | 0.14 | 20.43 | .000 | .64 | 0.540 | 0.20 | 18.85 | .000 |
| 1-9 | .40 | .240 | .11 | 14.90 | .000 | .45 | .307 | .11 | 18.48 | .000 | .66 | 0.415 | 0.11 | 23.26 | .000 | .49 | 0.471 | 0.16 | 20.20 | .000 |
| 1-10 | .40 | .215 | .11 | 13.52 | .000 | .48 | .265 | .09 | 19.11 | .000 | .60 | 0.356 | 0.08 | 25.71 | .000 | .37 | 0.419 | 0.15 | 19.27 | .000 |
| 1-11 | .36 | .194 | .09 | 14.12 | .000 | .54 | .228 | .08 | 19.78 | .000 | .63 | 0.300 | 0.07 | 26.33 | .000 | .38 | 0.356 | 0.12 | 19.65 | .000 |
| 1-12 | .38 | .194 | .09 | 10.04 | .000 | .55 | .227 | .08 | 11.11 | .000 | .71 | 0.263 | 0.05 | 28.33 | .000 | .39 | 0.318 | 0.10 | 21.47 | .000 |

Table 9 shows the SEb of aggregate scores for word identification. According to Table 9, mean scores of the SEb based on each student decreased as the number of data points increased. All of SEb for word identification were significantly different from zero.

Table 9. SEb of aggregate scores (Wks. 1-3, Wks 1-4, Wks, 1-5 etc) for Word ID

| Weeks | Grade 1 | | | | |
|-------------|---------|------|------|-------|------|
| | Slope | Mean | S.D | t | sig |
| 1-3 | 1.68 | 3.24 | 2.58 | 9.14 | .000 |
| 1-4 | 1.70 | 2.09 | 1.54 | 9.90 | .000 |
| 1-5 | 1.92 | 1.55 | 1.05 | 10.70 | .000 |
| 1-6 | 2.07 | 1.24 | .86 | 10.48 | .000 |
| 1-7 | 1.46 | 1.01 | .69 | 10.76 | .000 |
| 1-8 | 1.52 | .81 | .51 | 11.54 | .000 |
| 1-9 | 1.51 | .69 | .40 | 12.48 | .000 |
| 1-10 | 1.41 | .58 | .34 | 12.36 | .000 |
| 1-11 | 1.58 | .47 | .27 | 12.92 | .000 |
| 1-12 | 1.76 | .47 | .26 | 13.08 | .000 |

Discussion

The primary purpose of this study was to investigate how often progress monitoring measures in reading must be administered to obtain consistency in slopes. To answer the question, the data analysis was divided into two levels: group and individual. First, in terms of group level, the growth rate was calculated for the following data collection schedules: Weeks 1-6, weeks 7-12, every other even week, every other odd week, and weeks 1-5. The results showed that as the number of data points included increased, regardless of measures and grade level, the growth rates continuously increased. Thus, the more data points administered, the greater the growth rate. At the individual level, correlations between each slope (Wks. 1-3, Wks 1-4, etc) and the overall slope for measures was reported. The results indicate that the correlation between each slope (Wks. 1-3, Wks 1-4, etc) and overall slope increased as the number of data points used increased. Finally, the means of the SEb of the aggregate scores was investigated using OLS. The results showed that the mean SEb decreased as the number of data points increased.

In summary, the results from this study imply that consistency in slopes is related to the number of data points, indicating that more data points produce more consistent slopes. However, it is important to note that these results are based solely on the data collected for the present study. Decisions about how many CBM data points are necessary to ensure consistent slopes may vary across different participants and settings.

References

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