**Arvans Study Analysis**

The Arvans study summary analysis underestimated the effect of the Read Naturally group on oral reading fluency. The Read Naturally group had a large effect size of .81 for fluency. The control EAU group had a moderate effect size of .57 for fluency. Both groups had excellent fluency gains. It should be noted that the use of the Read Naturally Intervention was extensive at the school before the study was conducted. The teachers were well versed in the Read Naturally strategy. Students used Read Naturally materials in the first and second grade in the two years prior to the study. Also, some students in the EAU group used Read Naturally materials during the study. Due to this, it seems as though the EAU group may not have been demonstrative of a true control group. The difference between the Read Naturally group's .81 effect size and EAU's .57 effect size was .24 after eight weeks. An effect size difference of .24 is significant when extrapolated over a school year.

Ethan R. Van Norman, M.A., performed an analysis of the Arvans study that is similar to what appeared in the Christ and Davie study (2008). In the Christ and Davie study, the authors first calculated a slope estimate from three time points for each student in the EAU and the experimental group. The slope estimate represented the number of words read correct per minute (WCPM) improvement per week. The mean and standard deviation of slopes were then calculated for each group. The percent of improvement of the experimental group in relation to the EAU group was calculated. After this, the authors used the percent of improvement and applied it to an aggressive rate of growth (1.50 WCPM improvement per week). That value and 1.50 were each multiplied by 36. The difference between those two values was then interpreted as a hypothetical effect if the Read Naturally Intervention was delivered across an entire school year.

Van Norman conducted a similar analysis on the Arvans dataset. Slope estimates were calculated for each student from two observations eight weeks apart. The mean slope value for the experimental group was 2.92 WCPM improvement per week (SD = 1.54) compared to the EAU group, which had a mean slope estimate of 2.24 (SD = 2.36). The .68 difference in mean slope for the Read Naturally Intervention group represents a 30% improvement over the EAU group. Assuming an aggressive rate of growth of 1.50 WCPM for typical students, a 30% increase would translate to a 1.95 rate of growth. Extended across 36 weeks, this represents a net increase of 70 WCPM, compared to 54 WCPM with a typical rate of growth (1.50 WCPM improvement per week across 36 weeks).

Although not ideal, slope estimates from two time points have been used to summarize growth in previous CBM-R research studies (e.g., Christ, Silberglit, Yeo & Cormier, 2010). See the attached document for further details.

Another way to analyze the Arvans study is to use the Hasbrouck-Tindal Oral Reading Fluency Norms. This table suggests that third grade students at the 50$^{th}$ percentile have an average weekly improvement of 1.1 WCPM. Van Norman analyzed the Arvans dataset to extrapolate growth using these normative values. For third grade students, weekly growth estimates for students in the 50$^{th}$ percentile typically approximate 1.10 WCPM per week. Assuming the Read Naturally group's 30% improvement over the EAU group, and assuming the intervention is delivered for 36 weeks, a student in the 50$^{th}$ percentile, on average, would be improving at a rate of 1.43 WCPM per week. After 36 weeks, this would translate to an improvement of 51 WCPM compared to 40 WCPM if the student did not receive the intervention. This is a substantial difference. Thus, the performance of the Read Naturally group in the Arvans study is impressive when compared to the typical rate of fluency growth of third grade students.

Considering all of this information, Read Naturally programs should receive a positive effects rating for fluency. A timely reevaluation is critical so that WWC may change Read Naturally's effectiveness rating for fluency from mixed effects to positive effects.

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# Curriculum-Based Measurement of Oral Reading: An Evaluation of Growth Rates and Seasonal Effects Among Students Served in General and Special Education

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*Abstract.* Curriculum-based measurement of oral reading (CBM-R) is often used to benchmark growth in the fall, winter, and spring. CBM-R is also used to set goals and monitor student progress between benchmarking occasions. The results of previous research establish an expectation that weekly growth on CBM-R tasks is consistently linear throughout the academic year. The patterns of CBM-R growth were examined for a large sample of students ($N$ = 3808) from both general education and special education populations in second to sixth grades. Results support four general conclusions: (a) annual growth is more substantial within the general education population; (b) growth is more substantial in earlier elementary grades; (c) more growth occurs in the fall than the spring season (i.e., seasonal effect), especially within the early primary general education population; and (d) the seasonal effect is less pronounced within the special education population. Estimates of growth within and across seasons are presented and implications are discussed.

Curriculum-based measurement (CBM) is used to index annual student growth across the primary grades. Procedures and measurement metrics are developed for mathematics, spelling, written expression, and reading. CBM oral reading (CBM-R) rate is the most researched and well established of those available procedures (Wayman, Wallace, Wiley, Ticha, & Espin, 2007). CBM-R is used as an index of reading rate and fluency, which are identified as critical skills to target for instruction and intervention within the early stages of

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reading development (National Reading Panel, 2000; National Research Council, 1998). CBM-R outcome also functions as a robust indicator of overall reading development throughout the primary grades (Wayman et al., 2007).

CBM-R progress monitoring data are collected and used to evaluate instructional effects, determine when to modify the instruction, and evaluate response to intervention (Deno, 1985, 1986). Teachers who use progress monitoring data are likely to use more specific and measurable goals, rely more substantially on data to guide instruction, and modify instruction more frequently (Fuchs, Fuchs, & Hamlett, 1989; Fuchs, Fuchs, & Stecker, 1989). Progress monitoring applications of CBM-R have the potential to confer the most substantial benefit to students. Progress monitoring can be conceptualized as either interim benchmark/screening assessments when data are collected three to four times per year, or time series continuous assessments when data are collected daily or weekly.

Both interim and time series CBM-R data are plotted graphically and evaluated against goals and goal lines. Fuchs and Shinn (1989) recommended that the rate of expected growth should derive from local normative performance so that individual student achievement can be compared against the local normative performance of grade-level peers. A goal line is established by connecting the CBM-R data point for the observed level of performance from Week 1 (initial performance) to the expected/typical level of performance at Week 36 (ending performance). Once graphed, the goal line provides a graphic trajectory of expected growth for the academic year. Ongoing time series data are then plotted on the graph and evaluated against the goal line. For example, if a student's initial level of CBM-R performance in September was 20 words read correctly per minute (WRCM) and in May that student was expected to read 60 WRCM, then the expected annual growth is 40 WRCM across 8 months, or 32 weeks. That translates to ~1.25 WRCM per week of growth (1.25 WRCM = 40 WRCM/32 weeks). The goal line and trajectory of expected growth is based on the assumption of a monotonic and linear trend.

## Monotonic Linear Growth

Standards of expected performance within and across the year provide the foundation to establish instructional goals and goal lines. There are two influential studies that established standards of weekly CBM-R growth (Deno, Fuchs, Marston, & Shin, 2001; Fuchs, Fuchs, Hamlett, Walz, & Germann, 1993), which have application in both research and practice. Fuchs et al. (1993) analyzed a CBM-R data set comprised of 103 students in general education and 14 students in special education. Each student was assessed weekly for an entire academic year using CBM-R procedures. Although some students evidenced a negatively accelerating annual growth, the researchers concluded that annual growth is, on average, monotonic and linear. They also observed a negatively accelerating trend across grades. That is, the rate of CBM-R growth was positive in all grades, but the rate of growth declined in each successive grade. The resulting analysis yielded grade-specific estimates of standard and ambitious rates of growth—and *assumed* a pattern of monotonic linear growth. Respectively, the growth, determined by the number of WRCM, were 1.5 and 2.0 in first and second grade, 1.0 and 1.5 in third, 0.85 and 1.1 in fourth, 0.5 and 0.8 in fifth, and 0.3 and 0.63 in sixth.

Deno et al. (2001) analyzed a large data set comprised of 2675 students in general education and 324 in special education classes. The student sample was from school districts across the country. The researchers relied on the *assumption* of monotonic linear annual growth. Ordinary least squares regression was used to calculate weekly growth. The study yielded useful estimates of observed and expected growth across grades and populations. The authors estimated that beginning readers in the general education population can be expected to improve 2 WRCM/week until they achieve 30 WRCM; thereafter, students in the general education population can be expect to improve at least 1 WRCM/week. Researchers observed that students in the special education population demonstrated substantially less growth, which approximated 0.5–0.8 WRCM/week, unless they are provided with robust evidence-based instruction, which might improve the observed rate of growth to 1.39 WRCM/week.

Prior studies provide useful estimates of typical, ambitious, and expected rates of CBM-R growth; however, those estimates depend on the assumption that growth is monotonic and linear across the academic year. That assumption should be examined more closely to determine its veracity. The prior studies also rely on analyses that neglect the inherent nesting of students within classrooms and schools, which establish potential bias in the linear and quadratic functions derived.

## Improved Modeling of Annual and Seasonal Growth

Research is necessary to evaluate alternate models of annual growth and test the predominant assumption that annual growth is monotonic and linear. This study will evaluate both linear (constant) and piece wise (nonconstant) models of growth from fall to winter to spring; moreover, this study will employ the superior approach of linear mixed model (LMM) rather than that of ordinary least squares used in prior research (Deno et al., 2001; Fuchs et al., 1993).

Ordinary least squares only estimates the fixed effects, which assumes that all cases have identical parameter estimates for intercept and growth. This is a limitation when modeling CBM-R growth because it is likely to be an erroneous assumption in most cases. The results of published research provide evidence for substantial magnitudes of variance in both intercept and growth among students in a sample (Shin, Deno, & Espin, 2000; Stage, 2001). It is likely that the intercept and growth rates should be treated as random effects in many instances. LMM can be used to estimate both the fixed effects and the random effects, which are the intercepts and growth rates for individual student cases in the sample. LMM takes into account the variances within and across individuals in the sample. Finally, ordinary least squares requires that missing data are removed casewise whereas LMM can handle missing data, which is likely to yield less biased estimates of intercept and slopes while enhancing power (Duncan, Duncan, & Strycker, 2006). This approach facilitates analysis of both seasonal effects, as pursued by two previous studies (Ardoin & Christ, 2008; Graney, Missall, Martinez, & Bergstrom, 2009), and compares those effects to that of linear growth as assumed in other studies (Deno et al., 2001; Fuchs et al., 1993).

The calendar year was divided into three seasons for the purpose of this study. The seasons were defined by those periods between standard tri-annual assessment occasions: fall, winter and spring. The duration between fall and winter assessments defines the fall season, that between winter and spring defines the spring season, and that between spring and fall defines the summer season. If growth is consistent and linear throughout the calendar year, then there is no *seasonal effect*. Conversely, if growth is not consistent and linear throughout the calendar year, then there is a seasonal effect whereby there is more growth observed for some seasons than for others.

The summer season is the most distinct for the majority of students because they are not exposed to formal instruction. The rate of achievement is likely to decline in the summer months (Kim, 2004) unless formal instruction is provided through summer school programs (Stage, 2001). A seasonal effect in the summer is expected because the conditions for learning are substantially different from that which occurs in the spring and fall seasons. The effect, however, does not seem specific to those differences between summer and the academic year. Ardoin and Christ (2008) observed statistically significant differences in CBM-R growth between the fall and spring seasons. That is, among a sample of second-grade students there was more growth in the fall than in the spring season. That result replicated across three combinations of CBM-R passages sampled from the Dynamic Indicators of Basic Early Literacy Skills. A subsequent study aimed to replicate and extend those findings