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School, Meds, and Moms: Using the Standard Celeration Chart for a Contextual Analysis of Behavior

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Contextual factors can have a significant impact on treatment outcomes. However, systematic analysis is difficult in the absence of appropriate measurement tools. The Standard Celeration Chart provides a way for evaluating the effects of these variables through its standardization and availability of immediate data analysis and decision making. Standard Celeration Charts are presented demonstrating how the date synchronization feature of the Standard Celeration Chart is used to identify and assess the influence of contextual variables. Specifically, using the Standard Celeration Chart can make contextual analysis possible by illustrating how school enrollment status, medication changes, and inconsistent session attendance can be observed as factors critical to academic task performance.

Keywords: date synchronization, contextual analysis, confounding variables, Standard Celeration Chart

It is commonly accepted that there are variables influencing behavior outside the behavior scientist's purview (Cooper, Heron, & Heward, 2007; Fryling & Hayes, 2009; Sidman, 1960). These contextual factors can have significant impact on treatment outcomes in a clinical setting. Examples of factors that can affect treatment outcomes include, but are not limited to, variability in session attendance, tardiness, holidays that reduce session time, academic curriculum, behavior management strategies implemented outside the treatment environment, and medication changes. It is impossible to control for all possible contextual features of this sort in a clinical setting, and systemic analysis of such factors is difficult in the absence of sensitive measurement tools. The Standard Celeration Chart (SCC) provides a lens for evaluating the effects of these factors through its standardization (Kubina & Yurich, 2012). The sensitivity of the SCC's date-synchronization feature provides the benefit of analyzing data in calendar time (see Kubina & Yurich, 2012, pp. 159–160). In this article, we discuss how the chart can be used as an analytic tool for a contextual analysis. Data plotted on three Standard Celeration Charts and three corresponding conventional Excel graphs are presented to demonstrate the superior clinical utility of the SCC for detecting sources of variance in performance in real calendar time. In these demonstrations, the SCC was used to assess the influence of variables, including changes in schedule due to breaks in school, medication changes, and attendance. A discussion of how to use the SCC as a communication tool for interested parties and how it relates to the breadth of intervention strategies is provided.

Method

In the first demonstration, changes in behavior were detected due to a learner not attending school. Frank was a 7-year-old boy diagnosed with attention-deficit hyperactivity disorder (ADHD). Frank was referred for services at Fit Learning for reading remediation. Due to a history of noncompliance, data were recorded and charted for duration of work refusal for each session from the beginning of his enrollment. In an effort to account for variability in these data, phase change lines were added to his chart

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retroactively to indicate when school sessions began and ended.

In our second demonstration, the impact of medication on mathematics acquisition programming and a global progress-monitoring probe in the form of a curriculum-based measurement (CBM) was assessed. Cathy was an 11-year-old girl diagnosed with ADHD. Cathy was attending Fit Learning for mathematics remediation. Cathy's mother reported that Cathy had started a new medication on a particular date. This medication change was indicated on all of Cathy's skill acquisition, behavior reduction, and skill probe charts to analyze the potential effects of this medication across programming.

Jack was a 7-year-old boy diagnosed with dyslexia and the subject of our third demonstration. Jack was referred for services at Fit Learning for reading remediation. He had both on-site (i.e., conducted at the center) and off-site (i.e., conducted at his school) sessions. Weekly reading CBM measures were collected only during on-site sessions. Jack often did not attend on-site sessions. Patterns of attendance and nonattendance of on-site sessions were evaluated on Jack's weekly reading CBM measure.

Results

Contextual factors were recorded and analyzed using the SCC. Frank's data are displayed in Figure 1. The record floors indicate the total duration of the session (100 min). The dots represent total duration of work refusal minutes. Dots below the record floor indicate days where no duration of work refusal was recorded. While reviewing the data, the clinicians observed a 2-week period of decreased work refusal followed by an increase in work refusal across several weeks. Upon observing this pattern, periods of no school attendance (e.g., holiday break) and periods of school attendance were indicated on the work refusal chart. A period where Frank was not attending school is indicated from the dates December 29, 2013, through January 12, 2014, by dashed phase change lines on this chart.

Using the SCC, clinicians were able to glean that work refusal was more likely while Frank was attending school compared to when he was not attending school. These data are summarized in Table 1, where we can see that Frank engaged in an average of 7.75 min of work refusal per instructional hour while school was in session. During periods where Frank was not attending school, an average of 1.25 min of work refusal per instructional hour was observed. These observations indicate a correlation between school attendance and work refusal.

Cathy's data are displayed in Figure 2. Effects of medication changes were analyzed in the context of her performance on a fifth-grade math computation CBM. The dots represent correct digits written. The "x" represents incorrect digits written. Upon starting a medication regimen, a noticeable reduction in the variability of her math computation CBM performance was afforded by plotting these data on the SCC. Bounce envelopes were calculated using an electronic template for the SCC (Harder, White, & Born, 2004). Before medication changes, variability in performance was at $\times 3.25$. After Cathy started ADHD medication, the variability was reduced to $\times 1.59$. A statistical analysis shows that before medication, Cathy was performing at an average of 13.8 digits written per minute with a standard deviation of 5.58. After medication, Cathy's performance increased to an average of 24.45 digits written per minute with standard deviation of 3.81.

Jack's data are displayed in Figure 3. Effects of on-site session attendance were analyzed in context of his performance on a first-grade-level reading CBM. The dots represent words read correctly. The "x" represents words read incorrectly. Dots and the "x" symbol that are on the same vertical line are due to a technique referred to as "stacked dots," where multiple 1-min timings were conducted on the reading passage, and all of these timings are charted on the corresponding weekly line. Because data on the SCC are plotted in real calendar time, patterns of attendance were evidenced by the length of horizontal spaces between data points on the weekly per minute chart. Celerations across months of consistent on-site session attendance versus months of inconsistent attendance or nonattendance of on-site sessions were considerably different. Celeration lines on Jack's chart were calculated using the Quarter Intersect Method (Pennypacker, Gutierrez, & Lindsley, 2003). Periods of consistent on-site session attendance can be detected in the months of July and October. Jack's data show

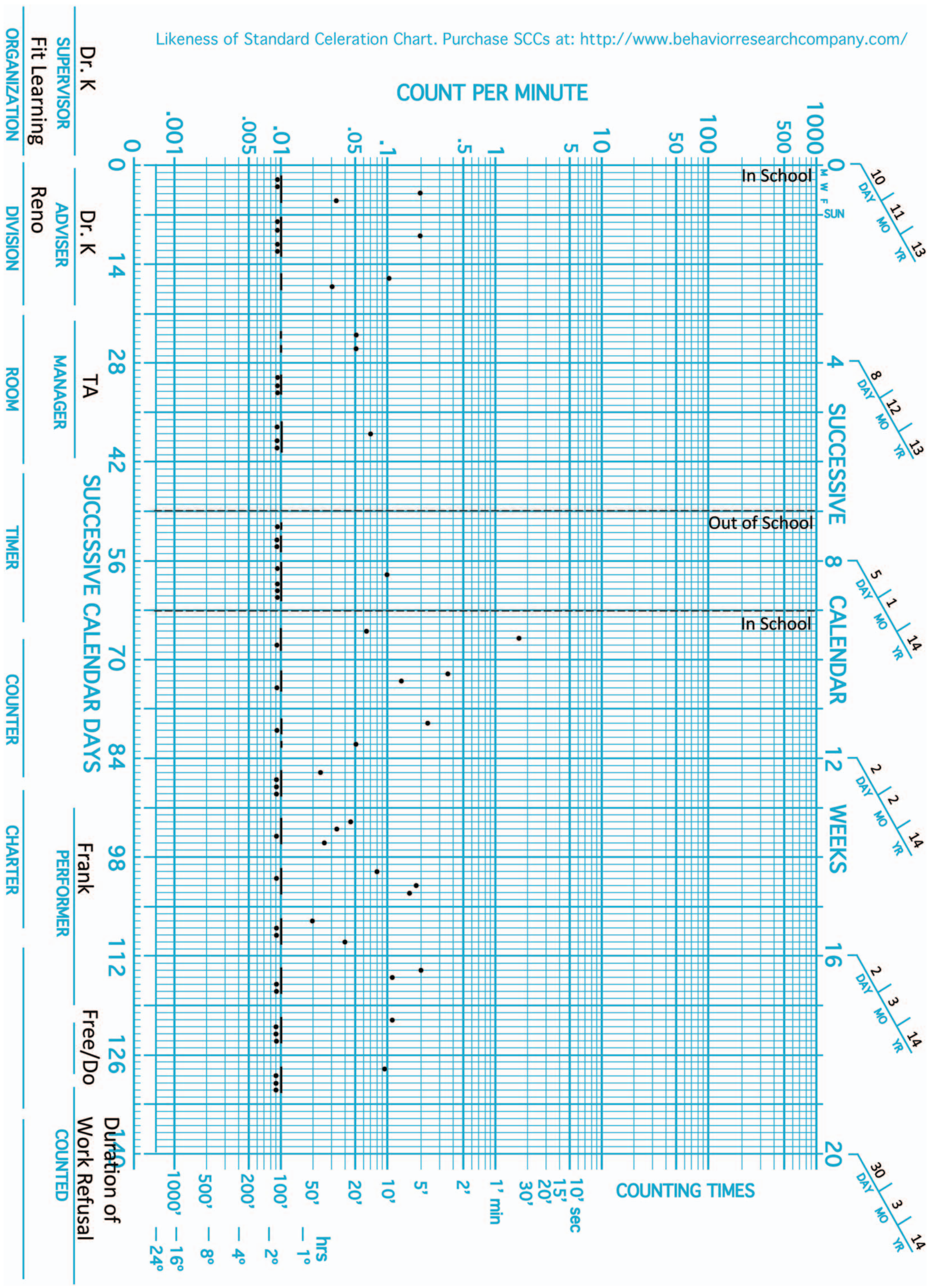

Figure 1. Frank's duration of work refusal during a 100-min session.

Table 1
Display of Frank's Instructional Hours and Work Refusal Minutes Separated Into Periods of School Attendance and Nonschool Attendance

Analysis period (November 10, 2013–March 23, 2014)	Total instructional hours	Total refusal minutes	Refusal minutes per hour of instruction
In school	57	441.75	7.75
Out of school	8	10	1.25

a $\times$1.33 celeration in July and a $\times$1.31 celeration in October. Periods of inconsistent on-site session attendance include August through September and November through March. Jack's data show a $\times$1.25 celeration in August through September and a $\times$1.06 celeration in November through March. Table 2 presents an analysis of Jack's percentage of on-site sessions attended. The steepest celerations in CBM performance correspond to months of high percentage of on-site sessions attended (e.g., July and October).

Discussion

The SCC provides behavior scientists with a valuable tool for evaluating the effects of both programmed and unprogrammed contextual factors. Specifically, the SCC's sensitivity and date synchronization feature have proved to be of particular value to assess the influence of contextual variables. By indicating variables such as the nonattendance of school, medication changes, or variability in attendance on the SCC, we are able to evaluate the effects of these unprogrammed events on behavior.

The data presented here are evidence of benefits of the SCC over other data management conventions such as graphing by session rather than calendar date. Use of another form of data display may have masked these sources of variability from the clinician. The use of nonstandardized data displays may make it difficult for the clinician to accurately evaluate rate of change, potentially exaggerating or muting the appearance of effects, and may negatively affect decision making (Kubina, 2014). To illustrate this point, we have included comparisons of the same data graphed using a more traditional Excel-based data display for each leaner (Figures 4, 5, and 6).

Frank's data are displayed on an Excel line graph in Figure 4 with sessions across the *x*-axis and percentage of time in work refusal across the *y*-axis. A period of decreased work refusal can be detected (between Sessions 14 and 28). However, the clinician would not have been able to put in phase change lines to indicate when Frank was in or out of school because data are plotted by session and do not correspond to specific dates. Additionally, it is important to note that Sessions 14–28 are not the sessions that correspond to when Frank was out of school. If the clinician were to only use the line graph in Figure 4, the functional relation between school attendance and work refusal would have gone undetected.

Cathy's data are shown using an alternative data display in Figure 5 with CBM weeks across the *x*-axis and percent correct across the *y*-axis. A phase change line could be indicated on this display because the parents provided the medication information the day that it went into effect. Detection of the same decrease in variability is evident in this display, as seen on the SCC it had been originally plotted on. At first glance, this may appear to not support our argument that the SCC provides a unique analytical vantage for clinicians. However, the purpose of this demonstration is not that Excel-created line graphs are inappropriate in all instances. Rather, it is to show the SCC is effective in providing clinicians with precise analytical vantage in all instances. Furthermore, Cathy's percent correct performance depicted in Figure 5 is not without limitation. For instance, although decreases in variability are detected and this detection can be linked to the introduction of a medication regimen, these changes are in different units of measure from those plotted on the SCC. More specifically, in Figure 5, the *y*-axis is percent correct, whereas the *y*-axis on a SCC is correct responses per minute. In the case of Cathy's performance, percent correct has improved, but what is not available for analysis on this conventional display is what

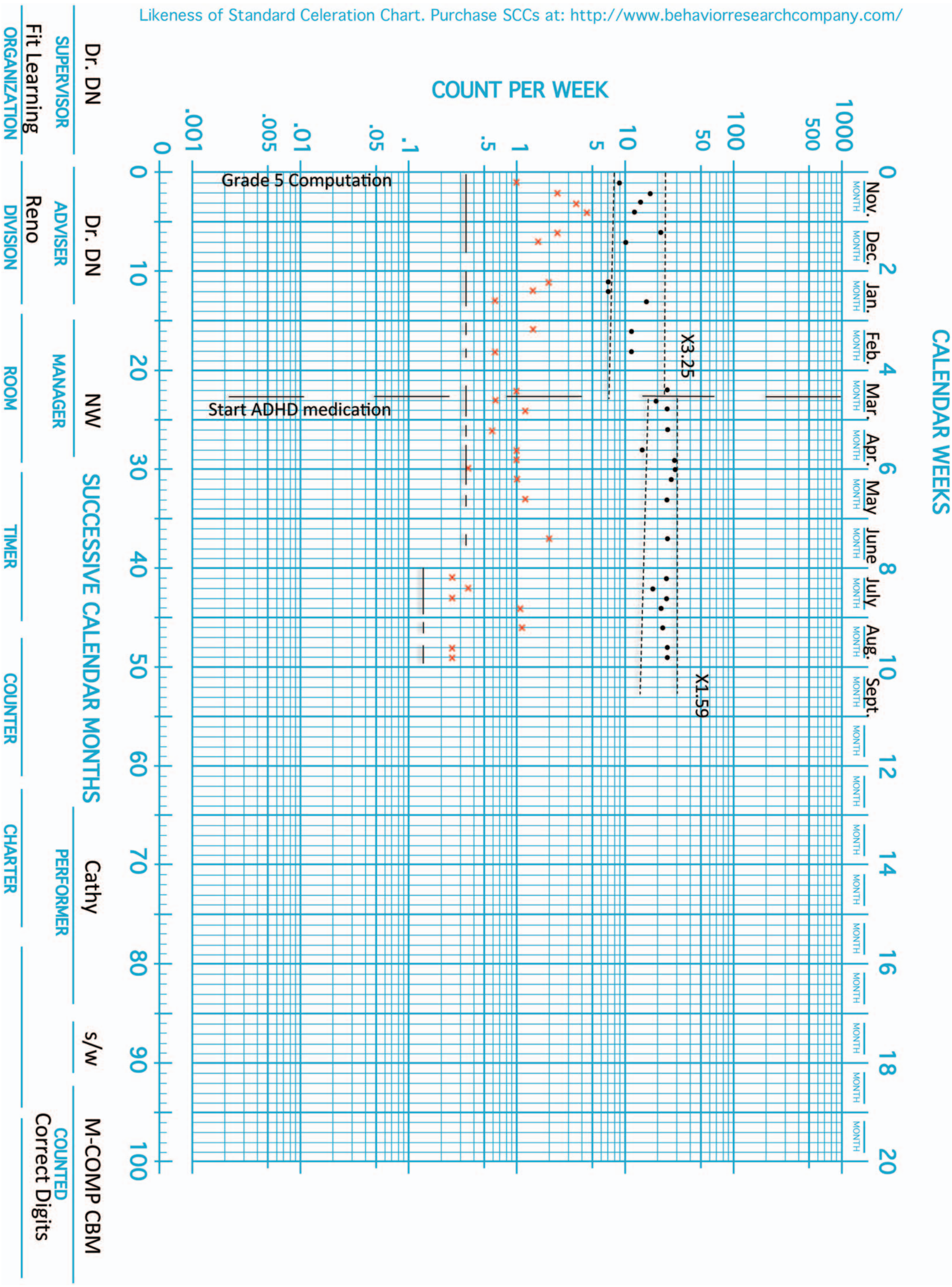

Figure 2. Frequency of correct and incorrect digits written on Cathy's math computation curriculum based measurement. ADHD = attention-deficit hyperactivity disorder.

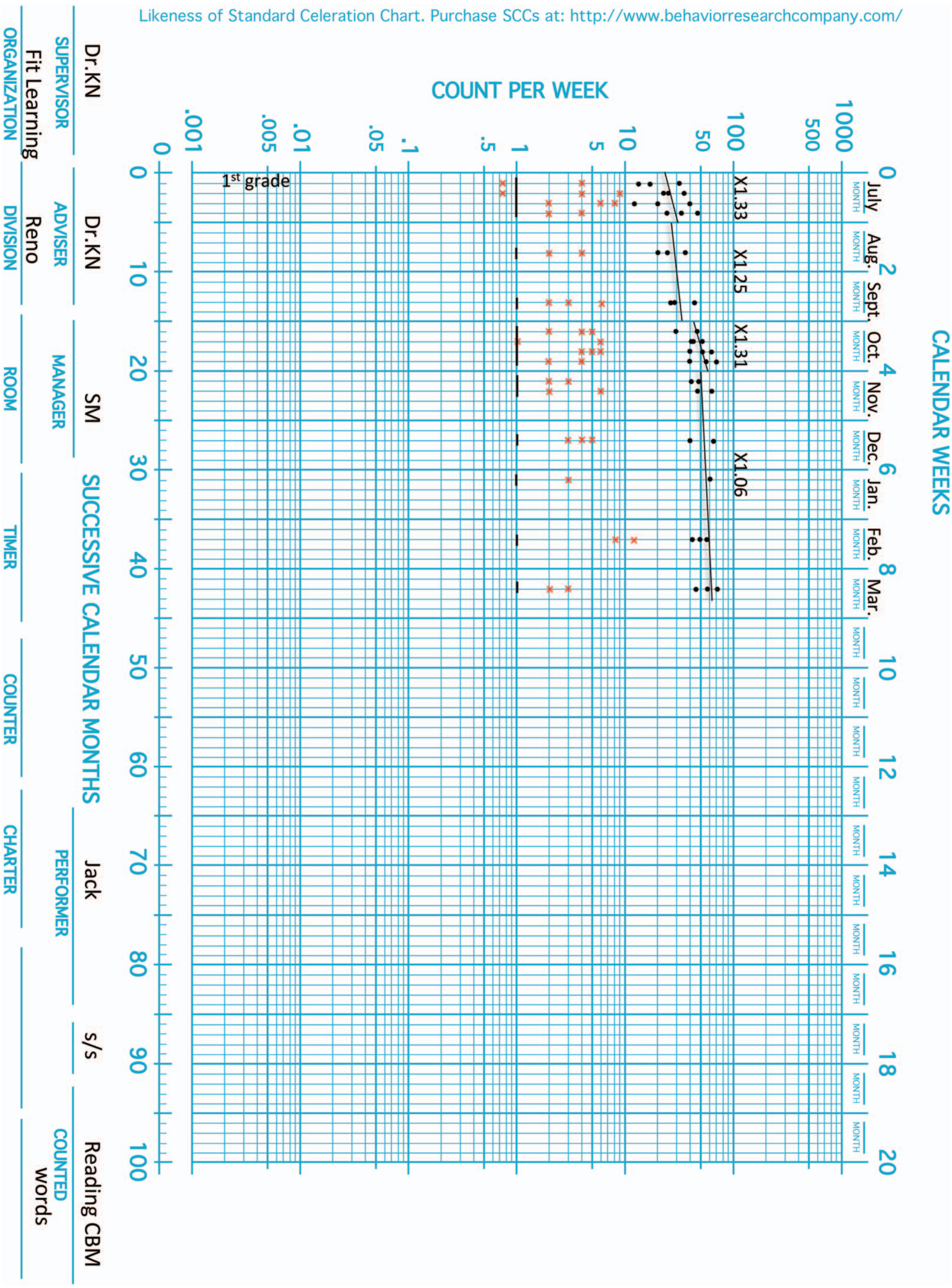

Figure 3. Frequency of correct and incorrect words read on Jack's reading curriculum-based measurement.

Table 2
Display of Jack's On-Site Session Attendance

Month	Percentage of on-site sessions attended
July	88
August	25
September	50
October	100
November	50
December	33
January	0
February	50
March	50

constitutes this statistical representation of behavior. For example, it might have been the case that her percent correct had improved, but the number of correct digits written decreased after the introduction of medication. This information could be determined using non-SCC conventions but would require additional displays. The SCC provides clinicians the analytical precision to evaluate multiple aspects of a learner's performance on one display without the need to create multiple graphs.

Jack's alternative data display (see Figure 6) is constructed with CBM weeks across the *x*-axis and percent correct across the *y*-axis. By excluding the date synchronization feature, this display method masks the variability in attendance of on-site sessions. Similarly to Cathy's graph analysis, by excluding the frequency count feature of the SCC, this alternative display also masks the comparison between progress during periods of on-site session attendance and progress during periods of inconsistent attendance that was clearly visible when data were displayed on the SCC. Again, these two comparisons display different units of measure (i.e., the *y*-axis on the line graph is percent correct, whereas the *y*-axis on a SCC is count).

The impact of using insensitive data displays potentially leads clinicians and researchers alike to false conclusions about the contributing factors. For example, given the same data without any reference to calendar time, one might have attributed the observed variability to a variety of putative explanatory factors (e.g., inadequate motivational operations, poorly selected or pinpointed curriculum, or poor program fidelity by instructors). Interventions based on these presumed factors would be unlikely to yield desired results because the underlying contributing factors would not be adequately addressed.

Discovery of contextual influences on performance from outside the treatment environment, such as those described above, is valuable not only to the clinician but also to other stakeholders. The standardization of the SCC makes it a particularly useful communication tool to be used with interested parties (e.g., parents and physicians). Even if effects of changes could be detected using other data display tools, the abil-

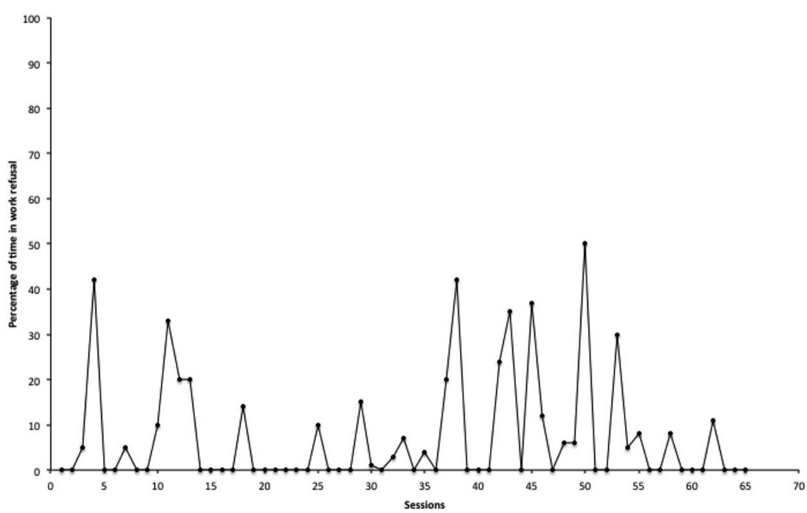

Figure 4. Frank's percentage of time in work refusal during each session.

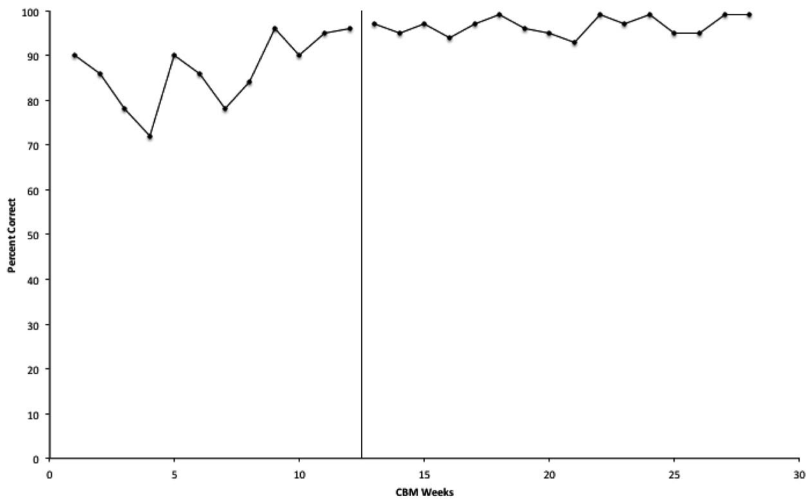

Figure 5. Cathy's percentage of correct digits written on a math computation curriculum-based measurement (CBM) before and after introduction of attention-deficit hyperactivity disorder medication.

ity to analyze these changes is limited by the reorientation required with each new display. Laypersons should not be expected to have the same data consumption skills as scientists. The SCC reduces the number of component skills required of the consumer by having a standardized display. A benefit of using the SCC as a communication tool is that charting conventions have be learned only one time, eliminating the need to relearn the dimensions of each chart (Kubina & Yurich, 2012). The use of the SCC as a data display tool makes communication more efficient due to its standardization. With Frank's SCC, behavioral differences noted during periods of no school attendance can be communicated to his parents and teachers. With data displayed on Cathy's SCC, the beneficial impact of the medication modification on her

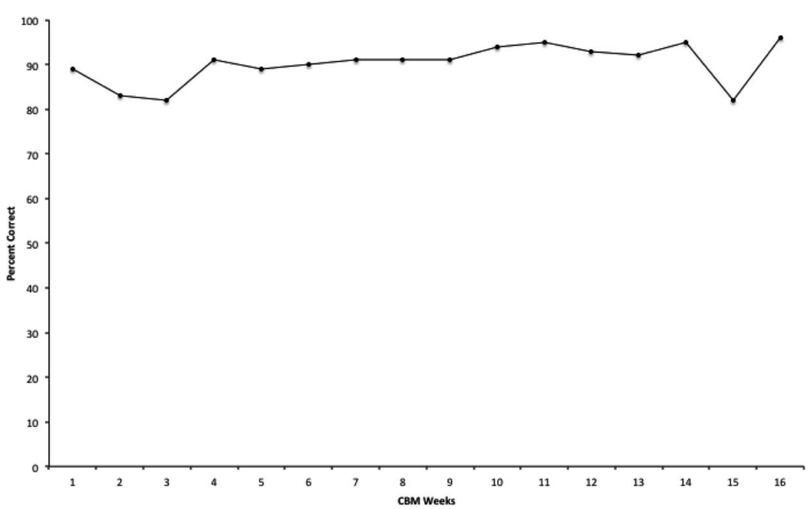

Figure 6. Jack's percentage of correct words read on a reading curriculum-based measurement (CBM).

grade-level math skills can be communicated to her caregivers and physician. Last, the importance of consistent attendance and the impact this variable has on grade-level progress can be made clear to Jack's parents.

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