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FREQUENCY AND THE STANDARD CELERATION CHART: NECESSARY COMPONENTS OF PRECISION TEACHING

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Abstract

Precision Teaching was founded by Ogden Lindsley and his students in 1965, and is essentially a movement advocating a science of human behavior and a practice of behavior change that includes the frequent observation and recording of behavior using a standard measurement unit, frequency, and a standard measurement scale, the Standard Celeration Chart. Lindsley adopted frequency, the standard unit of measurement used by Skinner(1938), and developed the Standard Celeration Chart. The Chart enabled Lindsley to determine the magnitude of human behavior frequencies, the change between two frequencies(frequency multiplier) and the change over seven or more frequencies(celeration). Some teachers and teacher trainers in the field of Precision Teaching are currently using non-standard measurement units like percent correct and count per opportunity rather than frequency. Since frequency is a standard unit of measurement, it cannot be changed without significantly affecting our understanding of human performance. In addition, some teacher trainers have truncated, that is, cut the Standard Celeration Chart and enlarged the remaining section, making it a non-standard, equal-ratio measurement scale. Since the Chart is a standard measurement scale like a meter stick, it cannot be enlarged(or, for that matter, reduced) without losing the absolute value and hence the understanding and interpretation of frequency, the frequency multiplier and celeration. The need to retain frequency and the Standard Celeration Chart(in its original size) as necessary components of Precision Teaching is demonstrated and discussed.

Many teachers, like the author himself, learned to collect children's frequencies and chart them on the

Daily Standard Celeration Chart without fully understanding the importance and implications of these two elements of Precision Teaching. We were like little children first learning multiplication facts. We did not yet understand the importance of those facts and how we could use them to solve complex problems in the future. In our first attempts as teacher trainers, we often encountered the following types of resistance and confusion: (1) a teacher would tell us proudly that a child "only missed three" or "did all ten correctly", having collected a "count" or "count per opportunity" without having conducted a timing; (2) a teacher would refuse to continue conducting timings, because, according to him/her, the timings made the children nervous; (3) a teacher would conduct timings, but still insist on changing the frequencies to "percent correct"; (4) a teacher would say that she couldn't mark the Chart because the lines were "too close together"; and (5) a teacher would either incorrectly mark a counting period floor for a counting period of greater than one minute, or correctly mark the floor and then count up from the one-per-minute line.

These types of resistance and confusion may have influenced some of us, whose teaching and using frequency and/or the Daily Standard Celeration Chart decelerated. Instead of changing our training methods, some of us permitted teachers to use count per opportunity and percent correct. Some teacher trainers, including the author, truncated, that is, cut the Chart so that most of the upper left hand quadrant remained. This new chart was then enlarged so that the frequency lines and day lines would be farther apart and so that the one-per-minute line would always be the counting period floor. These "new" behaviors were accelerated and maintained for several years. This may have been the result of the teachers, at least temporarily, using the charts, and the teachers no longer expressing resistance and confusion. For some teacher trainers, including the author, these behaviors were eventually extinguished, apparently by teachers discontinuing to use the truncated and enlarged charts and by colleagues refusing to "pay attention" to the charts. This extinction process, along with several explanations from colleagues concerning the importance of frequency and the Standard Celeration Chart, resulted in our return to teaching and using these elements. However, some Precision Teachers and teacher trainers are still using percent correct, count per opportunity or charts that have been truncated and enlarged. The purpose of this article is to demonstrate that frequency and the Standard Celeration Chart(in its original size) should be retained as necessary components of Precision Teaching.

In order to fully understand and appreciate frequency and the Standard Celeration Chart, it is necessary to understand the role of standard measurement in the natural and social sciences. In the natural sciences the direct and frequent observation and recording of phenomena using standard measurement units has been acknowledged for many centuries as a prerequisite for both scientific inquiry and everyday practical applications of science. For example, in chemistry, the volume of a liquid is measured in liters. The number of liters can be directly observed and recorded. Changes in the volume over frequent observations can also be recorded. Without liters, a standard measurement unit, there could be no observation of changes in the volume over time and no systematic investigation of variables that might affect the volume. Sometimes, to assist in the measurement of the magnitude of a phenomenon and the changes in that phenomenon, standard measurement units are displayed along a standard measurement scale. For example, in medicine, human body temperature is measured in degrees Fahrenheit or Centigrade, displayed along the oral thermometer ranging from 94-110 degrees Fahrenheit or 35-43 degrees Centigrade. The magnitude of a temperature and the change in temperature over frequent observations can be recorded. Without degrees, a standard measurement unit and the oral thermometer, a standard measurement scale, there could be no determination of the magnitude of a temperature, no observation of changes in the temperature over time and no systematic investigation of variables that might affect the temperature. If volume and body temperature were measured using multiple units of measurement and multiple measurement scales, there would be no science or practice of chemistry or medicine. We would learn almost nothing from these disciplines about how to improve the human condition and how to control and predict future events.

In the social sciences, attempts at the standard measurement of human behavior have focused primarily on the administration of infrequent, norm-referenced standardized tests, rather than on the direct and frequent observation and recording of specific behaviors using a standard measurement unit. This lack of a standard measurement unit for daily performance and a standard measurement scale to record weekly and monthly performance change has greatly impeded progress in developing a science of human behavior and in improving the practice of behavior change. According to Johnston and Pennypacker(1980), standard units of measurement and a standard measurement scale are necessary components to such a science and practice. According to Lindsley(personal communication, March 5, 1981), without standard units and a standard scale, the measurement of dependent variables and the change in those variables is a variable itself, and consequently of almost no utility. In other words, if some teachers use count and percent correct to measure the performance and progress of their students, while others use count per opportunity and duration, and all these measurement units are displayed on multiple measurement scales, the resulting information is of almost no use to teachers in determining precisely a student's strengths, weaknesses, and progress. This information is also of almost no use to researchers seeking to discover the major determinants of behavior.

Skinner(1938) was the first to suggest the direct and frequent observation and recording of behavior using a standard measurement unit. He used a unit of measurement in the animal laboratory that he interchangeably called frequency and rate(Skinner, 1938, 1953). Frequency or rate was defined as the number of times a behavior occurred per minute. He called this unit the universal datum of behavior. In the early 1950s, Lindsley, Skinner and Solomon(1953) adopted this unit of measurement and were the first to collect human behavior frequencies.

In 1965, Lindsley and his students began to use this same measurement unit with children and teachers in public school classrooms. In 1966, Lindsley and his colleagues developed the Daily Standard Behavior Chart(Pennypacker, Koenig and Lindsley, 1972; Koorland and Martin, 1975; McGreevy, 1983), which Lindsley later renamed the Daily Standard Celeration Chart. The Chart was an attempt to provide a standard measurement scale to display and determine the magnitude of a number of successive human frequencies collected over a short period of time. Using a logarithymic, equal-ratio (multiply-divide) scale, Lindsley and his colleagues discovered that they could display the full range of human frequencies(one per 24 hours- 1000 per minute) along six cycles of "x10". They decided to display these six cycles along the short side of an 8 1/2" x 11" sheet of paper. The resulting frequency scale was Count Per Minute. This left the long side of the paper for a measure of time. The 11 inches easily accomodated 140 days or 20 weeks, the approximate length of a public school semester, displayed along an equal-interval scale. The resulting time scale was Successive Calendar Days. The Daily Standard Celeration Chart is thus a standard, semi-logarithymic, equal-ratio (multiply-divide) measurement scale used for the display of daily frequencies.

From the Chart, Lindsley discovered two measures of behavior change-- the frequency multiplier and celeration. The former described the change between two frequencies, while the latter summarized the change in seven or more frequencies per week. These measures were constant across the entire range of human frequencies, that is, anywhere on the Chart, and were thus standard measures of behavior change. In sum, Lindsley became the first social scientist to develop and use a system for the standard measurement of the magnitude of specific human behaviors and the change in magnitude over frequent observations.

Frequency and the Daily Standard Celeration Chart became the foundation of a movement known as Precision Teaching. This movement includes many measurement and teaching strategies that were developed from this standard measurement foundation. Some of these strategies are: (1) one-minute timings, (2) child knows best, (3) try three-at-once, (4) the dead person's test, (5) learning pictures, (6) Chart-based decision-making, (7) high initial error frequencies, and (8) SAFMEDS. Some Precision Teachers have emphasized these strategies to the exclusion of either frequency, the Standard Celeration Chart, or both.

The Daily Standard Celeration Chart is a measurement scale like a meter stick(see Chart 1). The Chart measures the magnitude of a frequency by its location along the Count Per Minute scale relative to the one per 24 hour line or starting point of the scale in the same way that a meter stick measures the distance betwen two points by the location of a point along the stick relative to the "zero" or starting point of the stick. Ten per minute is always two-thirds of the way up the Chart, while 50 centimeters is always half way up the meter stick.

The Chart also measures the magnitude of a frequency multiplier as the distance between two frequencies along the same Count Per Minute scale. A frequency multiplier describing an increase in frequency from two per minute to 20 per minute is a specific distance along the Count Per Minute scale that has a value of x10. A frequency multiplier describing a corresponding decrease in frequency from 20 per minute to two per minute is the same distance along the scale in the opposite direction and has a value of /10. This same distance has the same x10 or /10 value everywhere along the scale. For example, the distance from one per 80 minutes to one per eight minutes and vice versa is this same distance and again has a value of x10 and /10, respectively.

Finally, to measure celeration, we must first draw a celeration line. This line is a best-fit straight line drawn through seven or more frequencies. The Chart, then, measures celeration as the distance along the Count Per Minute scale that a celeration line covers between successive Sundays along the Successive Calendar Days scale. The slope of this line has a value that corresponds to the value for the distance covered. A celeration line passing through successive Sundays at one per 10 minutes and one per five minutes describes an increase in frequency and covers a specific distance along the Count Per Minute scale that has a value of x2. The slope of this line has a value of x2 per week. A celeration line describing a corresponding decrease in frequency from one per five minutes to one per 10 minutes covers the same distance along the scale in the opposite direction. This distance has a value of /2 and the slope of this line has a value of /2 per week. This same distance and slope have the same value of x2 or /2 and x2 per week or /2 per week, respectively, everywhere along the scale. For example, a celeration line passing through successive Sundays at 12 per minute and 24 per minute and vice versa covers this same distance of x2 and /2, and has a slope of x2 per week and /2 per week, respectively.

As mentioned earlier, some Precision Teachers, including the author, have truncated, that is, cut the Standard Celeration Chart, enlarged the remaining section, and created an instrument that provides equal-ratio, but non-standard measurement. When you enlarge(or reduce) a measurement scale, you retain relative measurement, but lose the absolute value of each measurement unit along the scale. If you make an enlarged photocopy of a section of a meter stick, each centimeter in that section retains its relative proportion to all other centimeters in the section, but each centimeter has now lost its former absolute value and is, in fact, no longer a centimeter. In addition, a distance of three centimeters along the enlarged scale is no longer three centimeters. Since the Daily Standard Celeration Chart is a measurement scale like a meter stick, it cannot be enlarged without losing the absolute value of every part of the Chart.

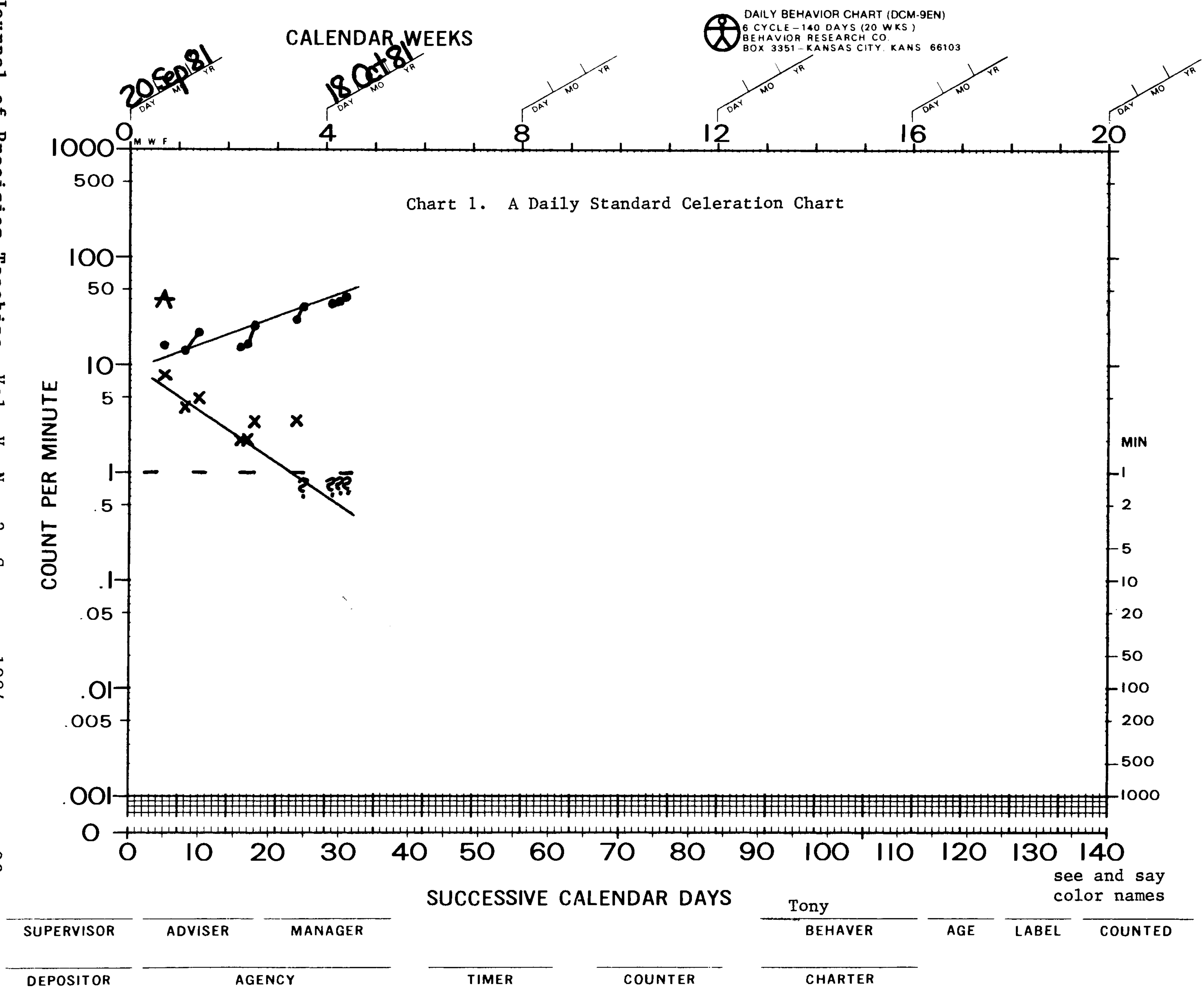

Chart 1. A Daily Standard Celeration Chart

Chart 1 displays 11 frequencies for Tony describing the magnitude of his performance on "see and say color names". These frequencies range from 16 to 41 per minute for the correct movement and eight to less than one per minute for the incorrect movement. Sixteen per minute is almost exactly 2/3 of the way along the Count Per Minute scale and is in the fifth cycle(10-100 per minute) of human behavior frequencies. Chart 1 also determines the x2 frequency(accuracy) multiplier between the initial frequency for the correct and incorrect movements. The x2 frequency multiplier covers a distance of 1/4 inch along the Count Per Minute scale. Finally, Chart 1 determines the x1.5 and /2 celerations for the correct and incorrect movements, respectively. The x1.5 and /2 celerations are lines with specific slopes that cover 1/8 and 1/4 inch distances per week, respectively, along the same scale.

Charts 2 and 3 display the same eleven frequencies on Standard Celeration Charts that have been truncated and enlarged. Chart 2 was initiated by the author in 1974 and disavowed by the same in 1979. Its use has been limited. Chart 3 was initiated in 1979 and is widely used today. Other truncated and enlarged charts are also in use today. The number of these charts and the extent of their use is unknown. On Charts 2 and 3, 16 per minute is now 55/100 and 45/100 of the way, respectively, along the Count Per Minute scale, giving a false impression of lower initial frequency or greater weakness. In addition, on these charts, there is no difference between a frequency of 16 per minute and 16 per day. On Charts 2 and 3, the x2 frequency(accuracy) multiplier is now a distance of 5/8 and 9/16 inches, respectively. This gives a false impression of greater initial accuracy. Finally, on Charts 2 and 3, the celeration lines have the same slope as Chart 1, but now cover 3/8 and 1/4 inch distances, respectively, for the correct movement and 5/8 and 9/16 inch distances, respectively, for the incorrect movement. This gives a false impression of higher celeration or more progress. With these truncated and enlarged charts, it is no longer possible to understand or interpret 16 per minute, a x2 frequency multiplier or a x1.5 celeration. With these charts, we have effectively "lost" all three standard measures of behavior.

Precision Teaching has the potential to make a significant contribution to a science of human behavior and the practice of behavior change. For the first time in human history, the elements necessary for such a science are available: standard units of measurement and a standard measurement scale. The standard measurement of dependent variables will enable us to precisely determine the effects of independent variables, the potential determinants of behavior. In addition, these elements will significantly improve the practice of behavior change. For the first time, the standard measurement of children's or adults' daily performance and weekly and monthly progress in school or therapy is possible. This means that we as teachers, therapists and researchers can more precisely determine, understand and interpret children's or adults' strengths, weaknesses and continuous progress. In addition, daily and weekly data-based decision-making can become a regular part of educational and therapeutic programming. If non-standard units of measurement and measurement scales persist, especially in the field of Precision Teaching, our chance for this understanding and improvement will be all but lost, and Precision Teaching will have been just another movement that contributed very little to either our knowledge of behavior or the improvement of the human condition.

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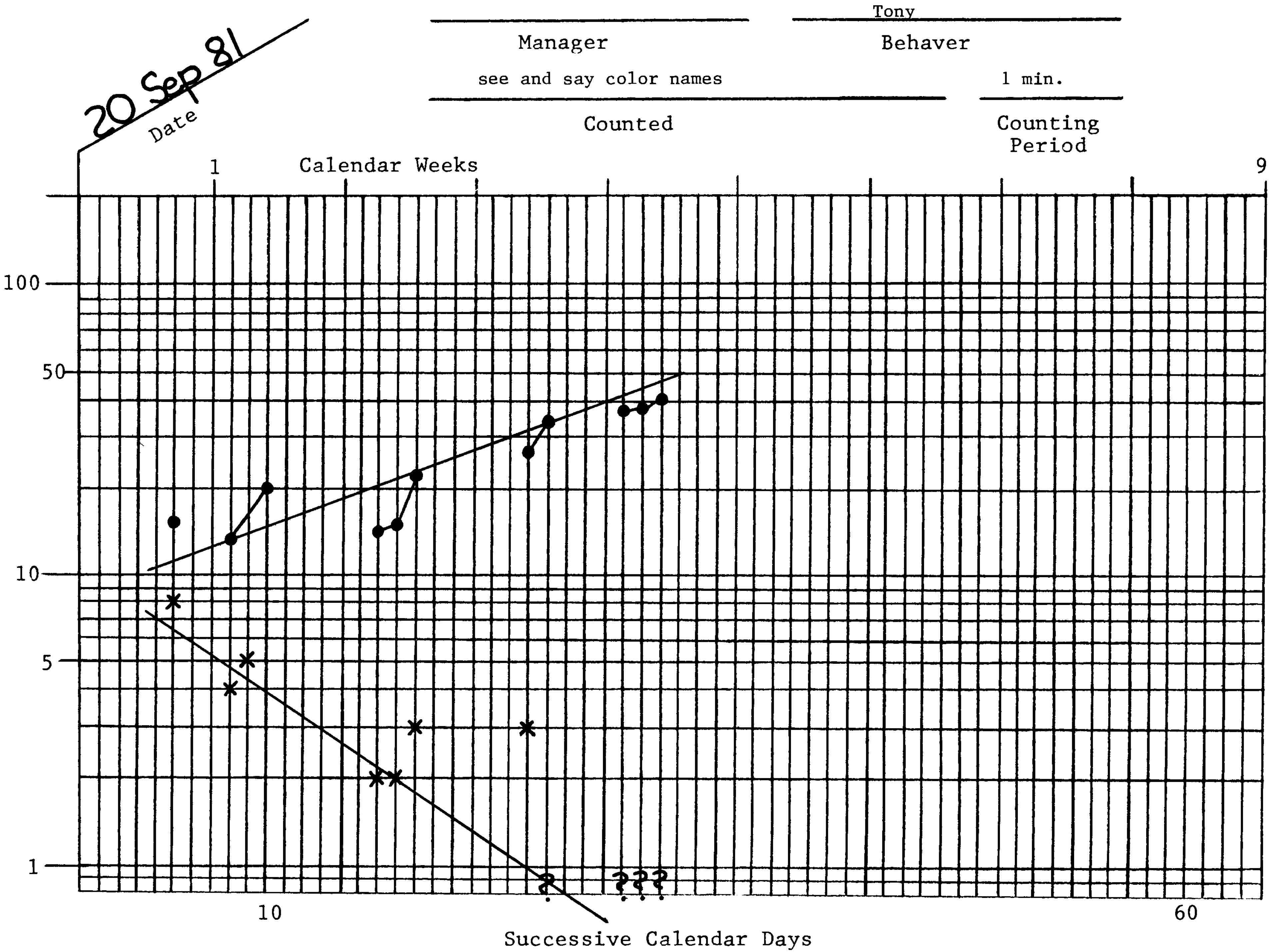

Chart 2. An Equal-ratio, Non-standard Chart

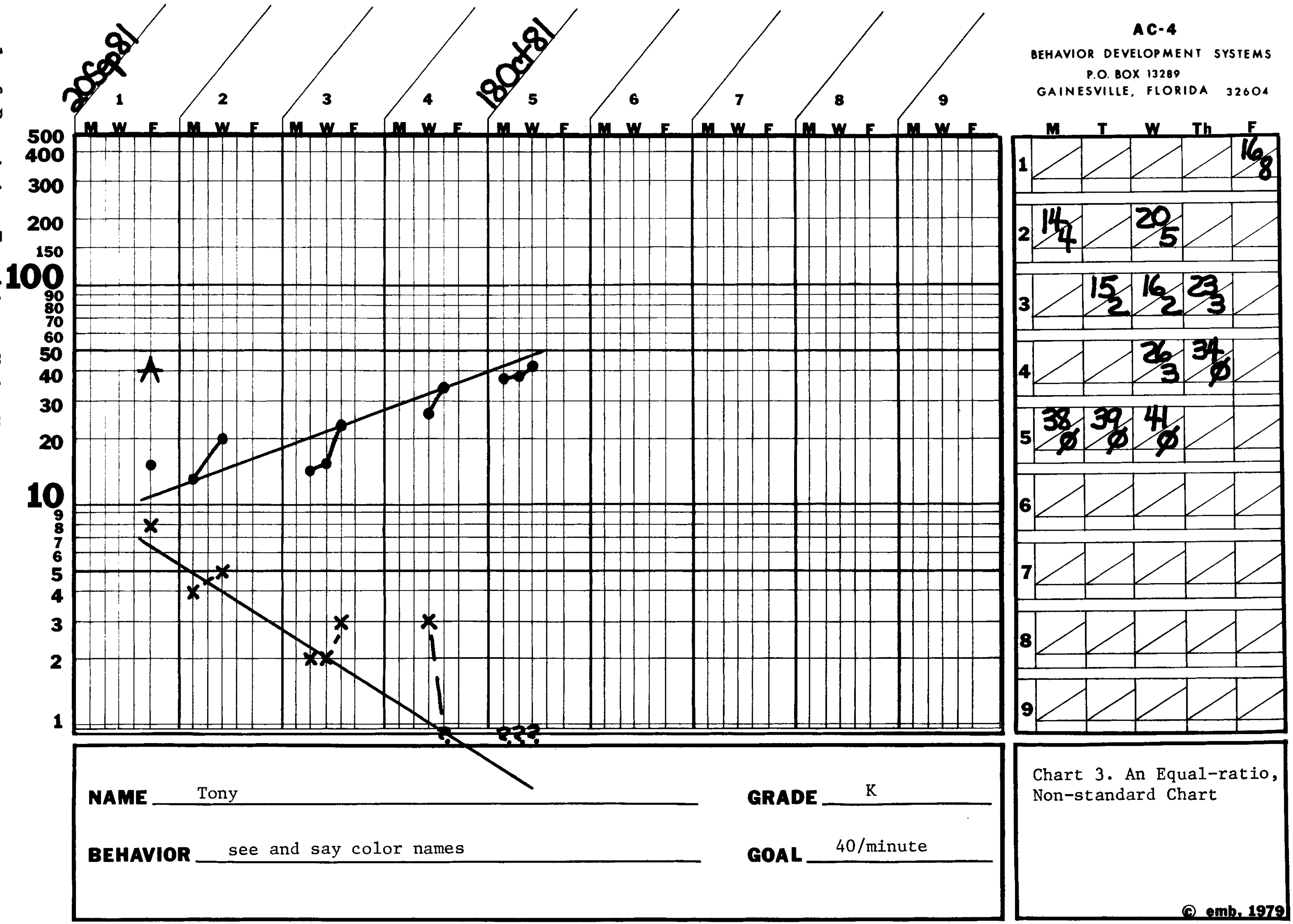

Chart 3. An Equal-ratio, Non-standard Chart

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OBTAINING A LEARNING PICTURE IN A HALF-HOUR

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You can generate a learning picture in a very short period of time, such as a half-hour. I have done so many times, using myself as subject, recorder, and charter. Instead of conducting one-minute timings daily over a period of several weeks, I have compacted these timings into about one hour of one day.

Part of the reason I came to do timings in this manner, over the course of an hour, can be attributed to the "Tender Loving Care Chart" (Haughton, Maloney & Desjardins, 1980), on which "SUCCESSIVE MINUTES" serves as the horizontal axis of the chart. Yet another reason was a statement made by Lindsley(1981) in which he indicated that you can collect in one hour, one thousand behavioral incidents with the continuous, direct measurement of free operant behavior. Lindsley was talking about the origins of Precision Teaching, but his comment served as a prompt for me to try "Precision Teaching in an hour". A final contributing factor was that I had been doing daily timings for several years with SAFMEDS, using myself as subject, and had become quite sensitive to many variables affecting performance (Eschleman, 1982).

The behavior of interest in all cases thus far has been "see-say with SAFMEDS"--"Say All Fast a Minute Each Day Shuffled" (similar to flashcards). A more appropriate term for the cards in the present case would be SAFMEMS--"Say All Fast a Minute Every other Minute Shuffled." The basic procedure was to do a one-minute timing with the SAFMEMS, going through as many cards as I could. Then, in the next minute, I counted and charted correct and error responses, and shuffled the cards. When this intervening minute timed out, I did another timing, followed again by another minute of counting, charting, and shuffling, and so on. A timing in all cases consisted of: (1) looking at the front of a card, (2) saying some response, (3) checking the answer on the back if necessary, (4) putting the card into a "corrects" or "errors" stack, and (5) doing the same for each succeeding card until the minute timed out. By following this procedure, it is possible to do 15 one-minute timings in a half-hour.

After 15 minutes a recognizable learning picture will begin to develop (see Chart 1). In my case, the pictures have all been "jaws", "crossover jaws", "climb", or "at aim" pictures. Since I plot the data on Daily Standard Celeration Charts with the horizontal axis re-labelled, I calculate celerations in terms of count/min./seven min., a measure analogous to the familiar count/min./wk.

Data

Chart 1 displays a recent series of successive one-minute timings. On March 29, 1984, I did 33 timings in 70 minutes. The SAFMEMS contained information about Apple II Machine Language commands (Inman & Inman, 1981). The function of the command was on the front of the card and the name of the command on the back. For example, "Load Accumulator" and "LDA" would be on the front and back, respectively (the terms I selected actually make up the instruction set