Therapy: An Experiential Approach to Behavior Change. New York: Guilford.

Merbitz, C. T., Miller, T. K., & Hansen, N. K. (2003). Cueing and logical problem solving in brain trauma rehabilitation: Frequency patterns in clinician and patient behaviors. *European Journal of Behavior Analysis, 4,* 45-58. First published in *Behavioral Interventions, 15* (2000): 169-187.

Moynahan, L. (2001) Relatio ergo sum. *European Journal of Behavior Analysis, 2,* 162-174.

Moynahan, L. (2003). Anvendt atferdsanalyse med sosiale systemer [Applied behavior analysis with social systems]. In S.Eikeseth & F. Svartdal (Eds.), *Anvendt atferdsanalyse: Teori og Praksis.* Oslo: Gyldendal Akademisk.

Salkovskis, P. (1996). The cognitive approach to anxiety: Threat beliefs, safety-seeking behavior, and the special case of health anxiety and obsessions. In P. Salkovskis (Ed.), *Frontiers of cognitive therapy.* New York: Guilford.

Salmon, S. (2003). *Peace curriculum.* Erie, CO: Center for Safe Schools and Communities.

Precision Teaching and Skinner's Legacy

Julie S.Vargas

B. F. Skinner Foundation

The five articles in this issue show the power and breadth of precision teaching. Ogden Lindsley, the founder of precision teaching, attributes its legacy to the work of B. F. Skinner. Precision teaching has adopted from Skinner, as Kubina & Starlin put it, "the use of a standard unit of performance, measurement, frequency and a standard display of visual data" (2003, p. 14). In these respects, the field follows in Skinner's footsteps more closely than does behavior analysis in general. When talking about teaching procedures, however, precision teachers usually adopt cognitive language, and ignore Skinner's analysis of verbal behavior. Precision teaching has much to contribute to behavior analysts and behaviorologists solely by its pinpointing of dependent variables, its measurement system, and its standard data display. Precision teaching, in turn, would gain even further effectiveness as a teaching technique by adding the functional analysis of Skinner's *Verbal Behavior* (1957/2000) to the evaluative power demonstrated by the five articles in this issue.

From Skinner's Work: Dependent Variables, Measurement, and Data Display

The Dependent Variable

In 1987, Skinner contrasted "methodological behaviorism" along with its correlate "logical positivism" with his own "radical behaviorism." The former two consider the private world of feelings and states of mind as "out of reach of science." Skinner, in contrast, says, "How people feel is often as important as what they do" (Skinner, 1987, p. 3). As E. Vargas put it, "The skin is a geographic boundary, not a boundary between the physical and metaphysical" (Vargas, 1982a). The dependent variable of behavior includes all behavior, including the "inners" described in Calkin's article. As she puts it, "inners" are "difficult to observe, but not different in kind from overt behavior" (Calkin, 2000/2003, p. 3). Many behavior analysts feel uncomfortable with depen-

dent variables that cannot be assessed by two independent observers, but as Calkin shows, precision teaching can handle human behavior inside the skin. Clinical treatments based upon Skinner's work, such as Joseph Cautela's "covert conditioning" have for many years used "inners" both as treatment variables and as measures of well being (Cautela & Kearney 1986). For example, in a study by Rushall (1993), an elite female rower was registering fewer and fewer revolutions on bimonthly ergometer tests over a three month training period. Increasing her workouts and weights had not helped. In a multielement design she tried three different "thought" procedures and was able to use the most productive one to reverse her decline and make the team, subsequently winning a bronze medal. As with precision teaching, her rowing strokes were timed, a level of precision similar to that in Calkin's article. No matter where behavior is located, precision teaching recognizes that it is measurable.

Measurement

Measurement is inexorably tied to the dependent variable in a science. Precision teaching maintains direct counts of actions over time, rather than indirect measures that in order to be understood require interpretation or comparison with norms. Furthermore it takes measures frequently, approximating Skinner's recording of every response as it occurred over time. The timing element in precision teaching produces rate data, the measure that Skinner once called his "greatest contribution."

All five articles demonstrate the advantages of rate over other measures such as percent correct. In fact, in some of them percent correct would have shown no change. Merbitz, Miller, & Hansen, (2000/2003) make that point. Since errors rarely occurred with their client, rate was the only measure that could be used to show improvement. A percent correct graph would have shown a straight line running across the top at 100%. In the Kubina and Starlin (2003) article, Leah in her last three weeks increased her speed of oral reading by over 50 words per minute. Percent correct would have shown no change because of the 100% correct perfor-

mance during that time. Similarly, Fabrizio and Moors (2003) show an increase in Jonah's rattle shaking of around 50 full shakes per minute. Without charting rate, improvement would be invisible. Rate reveals changes that cannot be seen using measures typically found in education.

The act of timing also sets up a special contingency for beginning right away and for working as fast as one can. In Calkin's case, those contingencies were critical for day to day improvement. They are also useful in education. Try a precision teaching timing with any skill such as writing sums of numbers to 20, pronouncing words, adding punctuation to a passage, or even the "uses of a brick" used to measure creativity, then watch students rush to begin when one says, "Go." Give the same tasks without timing and most of those same students will rearrange their papers, drop their pencils, or whisper to a peer; anything but begin right away. Timing provides motivational contingencies not only in starting work, but also right afterwards. The visual signs of improvement produced by charting rate data are almost always rewarding and set up SDs for "trying to beat one's own record."

Even worse than percent correct is the "time on task" or "percent of intervals" that creeps into graphs in the American *Journal of Applied Behavior Analysis*. No behavior is represented in the numbers shown. Furthermore, by rewarding "time on task," researchers may decrease disruptions but fail to improve productive behaviors. In fact, rewarding time on task often *slows down* whatever productive behaviors are going on during the counting period. As one fifth grader put it, "If you finish, they only give you more work." That is counterproductive: All of the present articles show how important fluency is both for immediate and for ultimate outcomes.

All educators talk about teaching that lasts beyond the schoolroom door. Precision teachers produce it. Kubina and Starlin (2003) give the fluency levels needed for elementary and secondary students' performances to last. McDade (2003/2000) recommends aims and/or celeration goals to produce improved undergraduate performance and increased graduation rates of "at risk" students. Fabrizio and Moors (2003) take a more detailed look at individual

performances, showing that not only can very young special education students meet high fluency aims, but that one can document "retention," "endurance," "stability," and "application" independently. Their recommendation to assess endurance, stability, and application before retention comes from data whose precision would not have been possible without setting goals in terms of rate and measuring number of productive behaviors over time.

Display of Data

Skinner's cumulative recorder showed every action as a tiny step upwards in a line that moved slowly to the right, providing a standardized record of every response as it occurred over time. The Standard Celeration Chart maintains two of the advantages of the cumulative record and approximates the third. First, the charts are standardized, as Merbitz et al. (2000/2003) and Kubina & Starlin (2003) emphasize. Once familiar with the format, a single glance gives a good idea of the impact of a procedure. Behavioral journals, in contrast, show graphs with differing coordinates, so that it is nearly impossible to compare outcomes of different studies or to judge the impact of a procedure without close inspection of the axes. Computer graphing programs produce graphs with data lines that fill most of a graph's space. They are designed for attractiveness, not for science. Science requires standardization, not beauty. The Standard Celeration Chart has kept the same coordinates for over 40 years.

Second, as Merbitz et al. (2000/2003) mention, "The timeline on the x-axis of the standardized graphs is 'real time,' not 'sessions,'" Just for a moment, think of the other axis of a graph. No one would remove "unneeded" numbers here and there from the vertical spacing along the y-axis. If a study produced values of only 3, 2, 5, and 12, no one would remove the sections of the y-axis for plotting 1, 4, and 6-7-8-9-10-11, just because in that study there were no data points for those values. Chopping sections out of the y-axis would distort the graph. But that is exactly what is done on the x-axis by most of the graphs in behavior analysis journals that put "sessions" on the bottom. Days on which experiments were not conducted are simply elimi-

nated from the spacing along the x-axis! Without real time along the bottom, trend lines are meaningless. It looks very different to go from a 10 to a 15 on successive days than if a week or month passes between the two data points. Patterns also disappear, such as the jump in performance following weekends shown in the Merbitz et al. Figure 3. Similarly, by plotting only sessions, one could not see the differences between Chris's improvement in successive days of work versus separated days that shows so clearly in the "furniture only" section of Fabrizio and Moors' (2003) Figure 4, but not in the performances shown in Figure 5. Only with all of the days shown can one get an accurate visual picture of what was done, when it was done, and the results as they occurred over time.

The third feature of Skinner's recording system, continuous measurement, is approximated in PT charts. Unlike the cumulative recorder, Standard Celeration Charts do not show every response at the exact point in time that it occurred. Each dot on the chart represents an average of the momentary variations in speed of responding that occur during the interval over which the count is taken. However, one must consider relative time scales. Most of Skinner's initial cumulative records covered only about 2 hours of behavior. The present charts span months. For these longer time scales, daily averages provide ample precision.

Because of the standardization and complete x-axes on the Standard Celeration Charts in the five articles, it is easy to compare performances between studies. One can easily see similarities or differences in the overall levels of actions per minute and in how quickly skills improved over time (celeration). Because of the logarithmic scale on the y-axis, even the variability of data can be compared between Standard Celeration Charts. Ratios between higher and lower data points, not intervals, are used to compare variability between studies. If the top values are twice the bottom values the spread will look the same on a Standard Celeration Chart no matter whether one is dealing with numbers in the single-digits or in hundreds. Thus not only can one compare the different charts in each study, one can see that the variability in Figure 6 of Merbitz et al.'s (2000/

2003) article is similar to that in the initial phases in Figure 3 in the Fabrizio and Moors (2003) chart, even though the frequencies in the latter are almost 10 times higher. In both, the higher values are roughly twice the lower.

Skinner's use of rate of actions and standardized recording of behavior over non-eviscerated time made possible the discovery of the operant—the heart of behavior analysis. Yet many behavior analysts dropped his measurement system when turning to human populations. The articles in this issue show the sensitivity of rate data, the benefits of standard graphs, and the advantages of temporal accuracy in displaying data. Behavior analysis would gain much from incorporating the rate data, measurement, and charting conventions of precision teaching.

Although calling itself precision teaching, the field is more Precision *Measurement* in its practices, as Owen White pointed out long ago when he wrote, "Precision teaching is not a way of teaching, but a way of evaluating whatever teaching strategies and curricula one might be using" (White, 1986, p. 530). This measurement emphasis is clear in the present articles. Merbitz et al. (2000/2003) used PT procedures "to evaluate an intervention curriculum." McDade (2002/2003) talks of the "feedback" that the charts provide saying that it "allows students and their learning services' staff or faculty to make necessary interventions to enhance performance." Kubina and Starlin (2003) also use precision teaching to "monitor instructional effectiveness." Fabrizio and Moors (2003) use precision teaching to assess "retention, endurance, stability, and application." Finally Calkin (2000/2003) measured success by her all-day counts of negatives and positives. Yet pedagogical prescriptions creep in. In Calkin's article, the timing and counting that comprised her treatment is both a form of measurement and a strategy for change. McDade says, "The most effective learning strategy demonstrated for over 23 years in Learning Services is practicing an accurate performance until fluency is reached" (p. 40). The same teaching procedures are echoed in Kubina and Starlin's recommendation for "consistent practice" and "direct repeated practice of the skill."

Skinner's Functional Analysis of Verbal Behavior: A "Not Yet" in Precision Teaching

Perhaps it is because of assuming accurate performance before working on fluency that precision teachers underemphasize shaping principles in favor of goal setting and timed practice, and that they ignore the entire field discussed in *Verbal Behavior,* the book that Skinner often called his "most important." Kubina and Starlin (2003) mention Skinner's book but then go on to use standard precision teaching expressions such as "See-Say," "learning channels," and "receptive language" that are incompatible with a functional analysis. Such expressions imply that learning consists of passing "information" from one person to another. A "word" learned is assumed to be "in" a person's vocabulary. Skinner looked at verbal behavior differently. To understand what a person says, writes, or gestures at any particular time, one must analyze its controlling variables rather than its form. The same "word" may occur under different controls and it is those controls that determine its meaning as well as the classification into which it falls. Skinner gives the example of the word "fire." "*Fire*" he says, "may be (1) a mand to a firing squad, (2) a tact to a conflagration, (3) in intraverbal response to the stimulus *Ready, aim...*, or (4) an echoic or (5) textual response to appropriate verbal stimuli" (Skinner, 1957/2000, p. 186). Mands and tacts differ in their controlling variables. As Lamarre and Holland (1985), and Hall and Sundberg (1987) have demonstrated, learning to say "spoon" when shown a spoon does not mean that a child can ask for a spoon when he or she (speaking loosely) "wants" one. A concern with differing controls is shown by Fabrizio and Moors (2003) when checking for "application," but they, too, use language incompatible with Skinner's functional analysis of verbal behavior.

Skinner's rejection of a formal analysis of language in favor of a functional one is not just a philosophical nicety. Recent advances in the treatment of autism have produced substantial gains in speed of acquisition of verbal behavior by changing the kind of verbal behavior first taught (Sundberg & Partington, 1998; Holth, 2000). Typically, teachers of children with no vocal lan-

guage started with tact or sequelic[1] training, for example teaching children to name objects presented by the teacher or to answer questions. It could take days or even weeks to teach a few "words." By shifting to mand training first, verbal behavior emerges rapidly, often in a matter of minutes or hours (J. E. Morrow, Co-Director of the ABC School for children with autism in Sacramento, CA, personal communication, March 2003). Even in a formal discrete trial format where participants have some vocal behavior, alternating mand and tact training cuts training time significantly (Arntzen & Almås, 2002). Starting with mands has another advantage. Where trainers in the past would repeat "Look at me" to get a child's attention, mand training can be arranged so that it is the *child* who seeks eye contact, as Holth has shown. When one considers the contingencies over the so-called "nonverbal" child, the reasons for the differing speeds of acquisition becomes clear. Mands are reinforced by a "characteristic consequence" (the object or event manded). Tacts and sequelics are built and maintained by generalized reinforcement, usually in the form of social approval, such as a teacher's "good job" perhaps paired with an edible or token. Since one characteristic of autism is insensitivity to social contingencies, it is not surprising that tacts and sequelics are more difficult to teach than mands.

Skinner's analysis does not require any particular form of emitting verbal behavior. A mand can be vocal, written, gestural, or even gross motor. Since mands produce a characteristic consequence supplied by others, many behavioral excesses turn out to be mands. Tantrums, for example, usually produce a "characteristic consequence" such as attention or escape from a task, and if under those immediate controls, are mands. By teaching a child more appropriate mand forms (such as taking a card to a teacher or saying "rest" or "break") inappropriate behaviors often decrease without requiring timeout or other decelerating consequences (Carr & Durand, 1985; Carlop-Christy, Carpenter, Le, LeBlanc, & Kellet,

2002; Winborn, Wacker, Richman, Asmus, & Greier, 2002).

In the Fabrizio and Moors (2003) article, Katherine's classification of flashcards as "boy" or "girl" falls into Skinner's category of tacting pictures.[2] Russell's "saying facts about topics" and Chris's "naming of objects in a category" are examples of sequelics. Even with their precision teaching procedures, Fabrizio and Moors needed several weeks to bring some of their children's skills to fluency. What they used as reinforcers is not specified, so it is difficult to tell whether starting with mand training could have contributed to even more rapid progress.

Just as precision teachers have not adopted procedures from Skinner's *Verbal Behavior,* those who use Skinner's verbal behavior framework typically do not use precision teaching. Most verbal behavior research uses trials, resulting in percent correct data. Combining the precision, sensitivity, and standardization of precision teaching's measurement and charting system with the power of functional analysis in Skinner's *Verbal Behavior* should give both fields what precision teachers call "leaps" in effectiveness.

Concluding Remarks

In spite of lack of use of Skinner's analysis of verbal behavior, precision teachers show the most important characteristic of a good teacher and a good researcher, namely sensitivity to data on performance. Responding to daily progress enables teachers to improve instructional procedures in what E. A. Vargas calls a cybernetic system of instruction (Vargas & Vargas, 1996). The more precise the feedback, the better. Fabrizio and Moors (2003) have raised feedback to the trainer to a new level with their checking independently for stability, endurance, and application. Merbitz et al.'s (2000/2003) research en-

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1. I will use E. A. Vargas's (1982b) term "sequelic" for what Skinner called "intraverbal." Vargas suggested using "intraverbal" for the whole category that Skinner called "verbal behavior under the control of verbal stimuli" which is much too clumsy for a category name.

2. Skinner defines tact as control by objects or events in the speaker's immediate presence. There is a continuum beginning with an actual boy, moving to an actual but dead boy, through successively less "realistic" boys, such as smaller reproductions or statues, videos, colored pictures, black and white line drawings, and finally to iconic representations (such as Chinese characters) which are clearly verbal stimuli rather than "objects or events." Saying boy in the presence of a Chinese symbol for "boy" falls into Skinner's "textual" category. Saying "tacting a *picture*" makes it clear that it is a picture, not an actual object that is controlling responding.

abled therapists to discover the impact of cueing on problem-solving and improve training accordingly. Even a glance at the charts presented by Calkin (2000/2003), Fabrizio and Moors (2003), and Kubina and Starlin (2003) reveals that treatment changes are not made at predetermined time intervals, but depend upon participants' performances. The articles in this volume thus demonstrate how precision teaching provides the precise feedback needed to further one's own effectiveness as an agent of change.

References

Arntzen, E., & Almås, I. K. (2002). Effects of mand-tact versus tact-only training on the acquisition of tacts. *Journal of the Applied Behavior Analysis, 35*, 419-422.

Calkin, A. B. (2000/2003). A minute a day makes good feelings grow. *European Journal of Behavior Analysis, 4,* 5-12. First published at *The Cambridge Center for Behavioral Studies*, 2000. Available: Everyday Life icon at http://www.behavior.org

Carr, E. G., & Durand, V. M. (1985). Reducing behavior problems through functional communication training. *Journal of Applied Behavior Analysis, 18,* 111-116.

Cautela, J. R. , & Kearney, A. J. (1986). *The Covert Conditioning Handbook*. New York: Springer.

Carlop-Christy, M. H., Carpenter, M., Le, L., LeBlanc, L. A., & Kellet, K. (2002). Using the picture exchange communication system (PECS) with children with autism: Assessment of PECS acquisition, speech, social-communicative behavior and problem behavior. *Journal of Applied Behavior Analysis, 35*, 213-231.

Fabrizio, M. A., & Moors, A. L. (2003). Evaluating mastery: Measuring learning outcomes. *European Journal of Behavior Analysis, 4*, 23-36.

Hall, G., & Sundberg, M. L. (1987). Teaching mands by manipulating conditioned establishing operations. *The Analysis of Verbal Behavior, 5*, 41-53.

Higbee, D. B., Lundell, D. B., & Duranczyk, I. M. (Eds.), *Developmental education: Policy and practice.* (Auburn, CA: The National Association for Developmental Education, 2000), 91-99.

Holth, P. (2000, September). TACTs and the role of 'joint attention': An operant analysis. Paper presented at the 6th International Congress on Behaviorism and the Sciences of Behavior. Auburn, AL.

Kubina, R. M., & Starlin, C. M. (2003). Reading with precision. *European Journal of Behavior Analysis, 4*, 13-22.

Lamarre, J., & Holland, J. G. (1985). The functional independence of mands and tacts. *Journal of the Experimental Analysis of Behavior, 43*, 5-19.

McDade, C. E. (2003). Success breeds success: Jacksonville State University's Learning services. *European Journal of Behavior Analysis, 4,* 37-44. First published in J. L. Higbee, D. B. Lundell, & I. M. Duranczyk (Eds.), *Developmental education: Policy and practice.* (Auburn, CA: The National Association for Developmental Education, 2000), 91-99.

Rushall, B. S. (1993). The restoration of performance capacity by cognitive restructuring and covert positive reinforcement in an elite athlete. In Joseph R. Cautela and Albert J. Kearney (Eds.), *Covert Conditioning Casebook*, 47-57. Pacific Grove, CA: Brooks/Cole.

Skinner, B. F. (2002). *Verbal Behavior*. Cambridge, MA: B. F. Skinner Foundation. (Original work published 1957)

Skinner, B. F. (1987, May 8). The place of feelings in the analysis of behavior. *London Times Literary Supplement*. Reprinted in B. F. Skinner, *Recent Issues in the Analysis of Behavior*, 3-11. Columbus, OH: Merrill Publishing Company.

Sundberg, M. L., & Partington, J. W. (1998). *Teaching Language to Children with Autism or Other Developmental Disabilities*. Pleasant Hills, CA: Behavior Analysts, Inc.

Vargas, E. A.(1982a). Hume's "ought" and "is" statement: A radical behaviorist's perspective. *Behaviorism, 10*, 1-23.

Vargas, E. A. (1982b). "Intraverbal behavior: The codic, duplic, and sequelic subtypes." *The Analysis of Verbal Behavior, 1*, 5-7.

Vargas, E. A., & Vargas, J. S. (1996). B. F. Skinner and the origins of programmed instruction. In L.D.. Smith & W. R. Woodward (Eds.) *B. F. Skinner and American Culture*. 237-253. Lehigh University Press: Bethlehem PA.

White, O. R. (1986). Precision teaching—precision learning. *Exceptional Children 52*, 522-534.

Winborn, L., Wacker, D. P., Richman, D. M, Asmus, J., & Greier, D. (2002). Assessment of mand selection for functional communication training packages. *Journal of Applied Behavior Analysis, 35*, 295-298.

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