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PRECISION TEACHING: DISCOVERIES AND APPLICATIONS

The Precision Teaching System: A Synthesized Definition, Concept Analysis, and Process

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Abstract
Precision teaching (PT) has a long history in the fields of behavior analysis and education. As the system of PT has evolved and grown, many developments and discoveries have been made. The current article briefly reviews the history of PT and presents a synthesized definition derived from the unique legacy of the system. The article includes (a) an updated definition of PT, (b) a concept analysis of PT, and (c) a set of synthesized steps that comprise PT. The goal of the current article is to present a succinct summary of the current state of PT for readers from all backgrounds, with examples that encompass the entirety of the applications of PT.

Keywords Precision measurement · Precision teaching · Standard celeration chart

The roots of precision teaching (PT) trace all the way back to Skinner's laboratory at Harvard. Ogden Lindsley, a student of B. F. Skinner's, extended the laboratory procedures used to validate the concepts and principles of behavior to human organisms. Using frequency of responding as his primary datum, Lindsley extended the use of behavioral principles in his Harvard Behavior Research Lab, the first human operant laboratory. These experiences led to the discovery that frequency was 10 to 100 times more sensitive than percentage-based measures (Lindsley, 1990). Using these experiences, Lindsley transitioned to the University of Kansas's Department of Special Education in 1965 (Potts, Eshleman, & Cooper, 1993). During this time, he, Eric Haughton, Ann Duncan, and Carl Koenig, among other graduate students of his, developed the standard celeration chart (SCC; A. B. Calkin, personal communication, January 26, 2020; Potts et al., 1993). The SCC, together with frequency of responding as the basic datum of measurement, led to the inception of PT.

Over the past few decades, many behavior analysts have adopted PT methodology into their practice. Firmly established as a behavior-analytic strategy, it was included as a basic competency for certified behavior analysts (Behavior Analyst Certification Board, 2012). With the growth of the field of PT, prominent precision teachers have proposed a spectrum of definitions, defining features, and processes. Varied definitions and descriptions of PT, combined with the presumption that PT functions as a specific method of instruction, have led to a misunderstanding of the system. The current article seeks to synthesize the historical developments of PT to create one succinct definition, a complete list of critical and variable features, and an updated set of steps to implementing PT.

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Synthesized Definition

We set out to present a definition of PT that includes all of the attributes we identified as "critical features," or the necessary attributes required in an example to be labeled "precision teaching." This process aligns with best practices in the instructional design literature, particularly Markle's (1975) description of an appropriate concept definition:

> The set of words which purport to be a definition should bear some clear relationship to the domain of the concept, where "domain" means the range of examples that

are to be included and the limits of the domain that separate examples from nonexamples. (p. 3)

Thus, a central aim of our work was to define the system of PT in a way that distinguishes examples from nonexamples of its use.

Process

To achieve this goal, we followed three steps. First, we evaluated 10 common definitions of PT from previous literature (see Table 1). This process helped illuminate common threads that clearly communicated what PT encompasses, as well as identify potentially confusing language that detracts from a consistent message. The historical context behind the language used and a present-day reflection on the impact of such language further warranted the development of a unified, contemporarily relevant definition. During this first step, we determined that no existing definition met that requirement. Second, we identified the critical features that, in our opinion, effectively described an example of PT using the preexisting definitions. We reconstructed an updated definition that looked similar to the existing definitions but also included all of the critical features. Third, we evaluated the new definition using a list of examples and nonexamples of PT. The

Table 1 Common Definitions of Precision Teaching

Definition	Author(s)
"Precision teaching is a monitoring, practice, and decision-making technology for improving performance of any kind."	Johnson and Street (2014) p. 581
"Precision teaching is not a way of teaching. Precision teaching is not another method of teaching. Precision teaching is not a refined behaviorist approach to teaching. Precision teaching is one way to plan, use, and analyze any teaching style, technique, method, or theoretical position—old or new."	Kunzelmann, Cohen, Hulten, Martin, and Mingo (1970) p. 12
"Precision teaching involves daily recording of the frequencies of different classroom performances on a standard chart."	Lindsley (1972) p. 115
"Precision teaching is adjusting the curricula for each learner to maximize the learning shown on the learner's personal standard celeration chart. The instruction can be by any method or approach."	Lindsley (1991) p. 259
"Precision teaching is basing educational decisions on changes in continuous self-monitored performance frequencies displayed on standard celeration charts."	Lindsley (1992)
"Mostly a monitoring, practice, and decision making system, precision teaching combines powerfully with any curriculum approach."	Lindsley (1997) p. 538
"Precision teaching is a measurement and decision making technology which uses frequency and rate of change in behavior as its basic data."	Maloney (1998) p. 119
"Precision teaching is not so much a method of instruction as it is a precise and systematic method of evaluating instructional tactics and curricula."	West, Young, and Spooner (1990) p. 5
"Precision teaching represents a set of procedures for deciding if, when, and how an instructional program might be improved to facilitate pupil learning."	White (1986) p. 1
"Precision teaching is a system for defining instructional targets, monitoring daily performance, and organizing and presenting performance data in a uniform manner to facilitate timely and effective instructional decisions. Precision teaching does not dictate what should be taught or how instruction should proceed. Rather, it represents a set of strategies and tactics for evaluating whatever program a teacher might choose to implement."	White (2005) p. 1433

purpose of this final exercise was to determine if the definition adequately described examples and clearly excluded closely related nonexamples (i.e., those instances that may resemble PT but do not meet all of the critical features).

Language in Existing Definitions

Existing definitions varied in their categorization of PT as a "technology" (Johnson & Street, 2014; Maloney, 1998), "system" (Lindsley, 1997; White, 2005), "method" (West, Young, & Spooner, 1990), or a "set of procedures" (White, 1986). We selected the term "system" as the best descriptor of PT, as a system refers to an interconnected set of specified elements working together to ultimately achieve a specific purpose (Meadows, 2008). This applies seamlessly to PT, as this system unifies interdependent critical features to serve the primary purpose of expediting learning outcomes. The PT system can perform a number of related functions such as (a) monitoring progress, (b) solving problems, (c) making discoveries, and (d) differentiating instruction (Kubina & Yurich, 2012).

A potentially confusing commonality among existing definitions involves their references to academic behavior and the classroom. Lindsley and his colleagues initially set out to introduce what we now refer to as PT to public school classrooms (Lindsley, 1990), so the language in much of the related literature reflects a focus on education. Lindsley selected the term "precision teaching" for this particular application, with the intention to use "precision" as an adjective added to the name of a specific professional application (e.g., precision counseling, precision social work; Lindsley, 1990a). Professionals have used the SCC successfully in other fields, such as social work (Green & Morrow, 1974), inner behavior (i.e., private events) and personal management (Calkin, 1981, 1992; Cobane & Keenan, 2002; Kostewicz, Kubina, & Cooper, 2000; Kubina, Haertel, & Cooper, 1994; Patterson & McDowell, 2009), ballet dancing (Lokke, Lokke, & Arntzen, 2008), and medical education (Dean, 1973; Rabbitt et al., 2020), but not all of these other fields added the word "precision" to their specialty (Lindsley, 1990).

Now, we often hear the term "precision teaching" used to refer generally to these broad applications. However, references to "classroom performances" (Lindsley, 1972), "curriculum/curricula" (Lindsley, 1991, 1997; West et al., 1990), "pupil" (White, 1986), "instruction" (Lindsley, 1991; West et al., 1990; White, 1986, 2005), and "teach/teacher/teaching/taught" (Kunzelmann, Cohen, Hulten, Martin, & Mingo, 1970; White, 2005) in existing definitions may evoke images of students in a classroom.

Rather than attempting to rename PT, we opted instead to more carefully define it. For the purposes of the current article, PT refers to applications of this measurement system to skill acquisition and fluency in any area. Our proposed definition refers to "accelerating behavioral repertoires," which encompass a vast majority of applications of the SCC to date.

The definitions that clearly stated variables that contributed to certain things being excluded as PT proved particularly useful in determining effective language for a definition that addresses any misconceptions of PT as an instructional method. Although PT is excluded as a specific method of instruction, some of the most successful precision teachers have maximized learning outcomes by combining PT with effective instructional design and delivery, including, but not limited to, direct instruction, frequency-building interventions, and element-compound or component-composite analyses (Binder & Watkins, 1990; Johnson & Layng, 1992; Johnson & Street, 2004; Johnson, Street, Kieta, & Robbins, 2020; Kubina & Morrison, 2000). These elements qualify as variable features because we have determined that they do not define the PT system. The PT system refers more explicitly to the measurement of behavior and analysis of intervention efficacy; thus, the application of the system can enhance and expand any skill-building intervention or teaching approach.

The most common themes across existing definitions included analyzing data to determine intervention effectiveness and making decisions based on those data. These themes reflect what we have observed in practice: Precision teachers tend to emphasize decision making with the SCC as the primary driver of (a) the effectiveness of PT related to client outcomes and (b) the value provided to practitioners and organizations by implementing PT. For this reason, we constructed the proposed definition to capture the centrality of these features.

Updated Definition

The researchers present the following synthesized definition based on the process described previously: PT is a system for precisely defining and continuously measuring dimensional features of behavior and analyzing behavioral data on the SCC to make timely and effective data-based decisions to accelerate behavioral repertoires.

Critical Features

The critical features of PT represent those features that define it. They comprise the "must-have" features (Layng, 2018), meaning that they must be in place in order to consider an application "precision teaching." If an instance lacks any one of the critical features, then that instance qualifies as a nonexample of PT.

Accelerating Behavioral Repertoires

When conducting a concept analysis of PT, the present authors grappled with reconciling the term "teaching" and its relationship to the actual practice of PT that we describe here. Does "teaching" only apply to academic skills? We do not believe so. What about focusing on instructional practices specifically, which is often how we use the word "teaching"? Not at all; PT relates more to the measurement of learning and responsiveness to patterns in the data than it does to the delivery of instruction. However, PT possesses something that justifies the term: Precision teachers embrace a *constructional approach* to solving behavioral and learning problems.

Goldiamond (1974) described a constructional approach as one "whose solution to problems is the construction of repertoires (or their reinstatement or transfer to new situations) rather than the elimination of repertoires" (p. 14). We have observed a clear focus in PT on building repertoires, reflected in the way precision teachers write goals, describe outcomes, use entry repertoires to guide programming, and primarily allocate attention to the acceleration of socially valid responses. Although precision teachers do measure deceleration targets (e.g., challenging behaviors, errors) and make decisions accordingly, they focus on building the acceleration targets as the ultimate goal.

To bring clarity to the collective understanding of PT, we propose that readers consider the word "teaching" in "precision teaching" to refer specifically to the acceleration of behavioral repertoires. This critical feature makes room for many practical applications, including accelerating positive health behaviors, teaching sales knowledge, increasing safety behaviors, and improving thoughts, feelings, or urges, in addition to the common applications in classrooms and tutorial settings. This necessarily excludes instances of using the SCC solely for the purpose of behavior reduction in the absence of any measurement of behaviors to accelerate. It also excludes instances of using the SCC to monitor nonbehaviors, such as economic or demographic trends, the prevalence of diseases, and changes in policy. These uses of the SCC are certainly valid, but we argue they require a different defining term that does not include the word "teaching."

Precise Behavior Definitions

Practitioners of PT define behavior in a very specific way, using a descriptive system called "pinpoints." Precision teachers use the term "pinpoint" in a similar way to the usage of the word in the common vernacular. Pinpoints ensure that individuals define behavior in a way that allows an observer to detect and measure it accurately—a factor that can improve both the reliability of measurement and treatment integrity (Smith, Lambert, & Moore, 2013).

Some variability exists among precision teachers with respect to conventions for pinpointing behaviors. Pinpoints always specify the movement cycle and can further specify (a) a learning channel set and (b) a context statement (Kubina & Yurich, 2012). A movement cycle clearly defines the beginning, middle, and end of a response—a full cycle of the behavior. The response must be observable and repeatable and contain movement (Kubina & Yurich, 2012). Precision teachers meet these criteria by constructing a movement cycle with a specific action verb in third-person singular present tense, followed by the object receiving the action in singular form. This allows for better calibration of measurement (e.g., "reads word" clearly establishes the beginning and end of each count of the behavior, but "reads words" does not specify when a series of words begins and ends). Some examples of movement cycles include "greets driver," "runs mile," "raises hand," "says praise statement," and "kicks soccer ball."

A learning channel set describes a sensory contact the learner makes with the stimulus/stimuli and a physical response modality of the behavior (Haughton, 1980). For example, when teaching greetings, a precision teacher may select the learning channel set "see-say," in which the learner sees a person and emits a vocal response. Alternatively, if the teacher wanted to instruct the learner on how to respond to greetings, the teacher would use the learning channel "hear-say," where the learner hears the greeting and says an appropriate response. See Table 2 for examples of common sensory contacts and response modalities.

A context statement can clarify in a few words the relevant context for where, when, with whom, or with what that movement cycle will be observed and recorded (Kubina, 2019). The context statement "when entering the bus" describes both a moment in time and a location in which the behavior occurs. Combining all three elements creates a pinpoint (e.g., see-say greets driver when entering the bus). This gives precision teachers a specific data target that will inform observers, instructors, and chart readers of the precise behavior of interest. See Table 3 for examples and nonexamples of correctly constructed pinpoints.

The specificity of pinpoints often reflects a very individualized approach to behavior description and measurement inherent in the PT system. Although some common pinpoints emerge over time that analysts may assign to a majority of learners in the same program, variations in learners' needs may require tweaks to learning channels, verb selection, and contextual descriptors.

Continuous Observation

PT is predicated on the continuous observation of behavior, in which individuals observe each instance of the behavior in real time during some length of an observation period. The continuous recording of behavior served as a critical feature of

Table 2 Stimulus Contact and Response Modality Guide for Learning Channels

Stimulus Contact												
	Free	Free-Aim	Free-Do	Free-Draw	Free-Emote	Free-Mark	Free-Match	Free-Say	Free-Select	Free-Tap	Free-Free	Free-Write
	Touch	Touch-Aim	Touch-Do	Touch-Draw	Touch-Emote	Touch-Mark	Touch-Match	Touch-Say	Touch-Select	Touch-Tap	Touch-Free	Touch-Write
	Taste	Taste-Aim	Taste-Do	Taste-Draw	Taste-Emote	Taste-Mark	Taste-Match	Taste-Say	Taste-Select	Taste-Tap	Taste-Free	Taste-Write
	Sniff	Sniff-Aim	Sniff-Do	Sniff-Draw	Sniff-Emote	Sniff-Mark	Sniff-Match	Sniff-Say	Sniff-Select	Sniff-Tap	Sniff-Free	Sniff-Write
	See	See-Aim	See-Do	See-Draw	See-Emote	See-Mark	See-Match	See-Say	See-Select	See-Tap	See-Free	See-Write
	Hear	Hear-Aim	Hear-Do	Hear-Draw	Hear-Emote	Hear-Mark	Hear-Match	Hear-Say	Hear-Select	Hear-Tap	Hear-Free	Hear-Write
	Feel	Feel-Aim	Feel-Do	Feel-Draw	Feel-Emote	Feel-Mark	Feel-Match	Feel-Say	Feel-Select	Feel-Tap	Feel-Free	Feel-Write
		Aim	Do	Draw	Emote	Mark	Match	Say	Select	Tap	Free	Write
		Response Modality										

Examples come from Kubina and Yurich's Academic-Personal-Social Learning Channel Matrix (2012, p.78), which included an updated version of Eric Haughton's Learning Channel Matrix designed in 1976, shared in Haughton (1980).

B. F. Skinner's cumulative recorder, on which Lindsley and colleagues modeled the SCC (Lindsley, 1991). Although the automatic recording provided by the cumulative recorder has historically been unattainable in many applied settings, adherence to the continuous observation of behavior yields data that most closely represent actual dimensions of behavior (Springer, Brown, & Duncan, 1981).

To ease the burden of observing behavior continuously in applied settings, some behavior analysts adopted event and time sampling procedures (e.g., partial and whole interval, momentary time sampling) made popular by child development researchers (Goodenough, 1928; Horn, 1914; Olson, 1929; Olson & Cunningham, 1934). Although applied behavior analysts have increasingly adopted these methods over time (Barrett, 1987) and have made meaningful discoveries about behavior, researchers have for many years cautioned against the widespread use of discontinuous observation. Springer et al. (1981) summarized the measurement error produced by discontinuous observation (i.e., overestimation or underestimation of actual response frequencies and durations) and recommended strongly that behavior analysts find ways to return to direct, continuous observation practices to further propel the science.

Precision teachers have rejected this trend over time and have held tightly to direct, continuous observation. Although precision teachers may observe behavior in samples of time when necessary (e.g., 10-min observation periods), the defining feature is that each instance of the response class of interest is detected and measured (e.g., all instances recorded within the 5-min counting time), rather than some derivative or estimate. Continuous observation has remained at the forefront of PT in large part due to the heavy emphasis on dimensional measurement within this system.

Dimensional Measurement

Measurable features of behavior include (a) repeatability, (b) temporal locus, and (c) temporal extent (Cooper, Heron, & Heward, 2007). All of these dimensional qualities of behavior include count and time. PT practitioners count and time behavior, most often selecting frequency (i.e., count per time, as in count per day, count per minute, count per year, etc.) as a measure, but may also measure latency, duration, or interresponse time of an instance of behavior, depending on the behavior being targeted.

The predominance of dimensionless measurement in applied behavior analysis evolved via the extension of laboratory-based science to practice in educational settings. Dimensionless measurement refers to procedures that yield an estimate of the behavior but fail to directly measure any dimensional quality of behavior. For example, according to Lindsley (1992), Bijou used cumulative recorders in his laboratory at the University of Washington but recorded the

Table 3 Examples and Nonexamples of Pinpoints

Pinpoint Examples	Pinpoint Nonexamples With Description
see-says numeral on page	*says numeral*
	Does not specify sensory contact with stimulus
see-says name of object	*free-do waits in line*
	Waiting is not an action
hear-says definition from term	*hear-do followed instructions*
	Written in past tense and not present tense
free-do pinches clothespin with forefinger and thumb	*free-do throws*
	Does not specify the object receiving the action

Note. Pinpoints are italicized for reference.

percentage of time on task and the percentage correct in his experimental classrooms. Percentage does not indicate how often a behavior occurs. Rather, it specifies the ratio of how often the behavior occurs in relation to a set amount of opportunities. Fred Keller identified percentage correct as the measure of academic success in his personalized system of instruction (Keller & Sherman, 1982). The use of frequency in Say All Fast Minute Every Day Shuffled (SAFMEDS), a PT application, serves as a notable shift in measurement practice used within this system (Johnston & O'Neil, 1971; Johnston & Pennypacker, 1971). Percentage correct ascended in applied behavior analysis publications (Barrett, 1987), but precision teachers held fast to dimensional measurement.

Due to the intense focus on ratio measurement within PT, precision teachers remain keenly aware of the detriments to both performance and decision making brought about by discontinuous (e.g., interval recording) and derivative (e.g., percentage) measures of behavior. First, these procedures place measurement-imposed ceilings on performance when the dependent measure used to quantify behavior has an absolute limit. For instance, when measuring the percentage of questions answered correctly, students cannot score higher than 100%, thus a learner cannot perform above that measure. This can distort the overall performance across time and presents a second problem with dimensionless measurement: These measures pose the risk of insensitivity to change across time. For example, on Monday, Rama answers 100 questions correct in 5 min with zero errors—an accuracy score of 100%. However, on Tuesday, Rama answers 20 questions correct in 5 min with zero errors. Although she is 100% accurate, her performance dropped immensely between the 2 days. By focusing on dimensional measurement—in this case, frequency of responding—we can detect a decay in her performance and make decisions to address this issue accordingly.

In addition, dimensionless measures mask critical information about the learner's performance. This leads to a third detriment: Dimensionless measures may not capture differences between performers. For example, both Jamar and Geetika earned 100% on the midterm; however, Jamar spent 3 hr completing the exam, but Geetika only required 1 hr. Using dimensional measures of behavior allows one to detect such differences in performance among learners. Precision teachers have decades of charts showing that dimensional measures of behavior are far more sensitive to change than percentage-based measures (Lindsley, 1990). Consequently, precision teachers adhere to a measurement system sensitive enough to remove ceilings, capture performance differences, and clearly represent change across time.

Standard Celeration Chart

The SCC offers a standardized visual display. The vertical *y*-axis displays a count per time units in equal ratio cycles of x10. The horizontal *x*-axis displays equal intervals of a continuous measure of time. Dark vertical lines on the chart represent calibrated standard celeration periods. The most commonly used SCC, the daily per minute, displays a count per minute on the *y*-axis across calendar days, with a celeration period of 7 days. The SCC includes all elements of a correctly constructed line graph for time-series data (Kubina, Kostewicz, Brennan, & King, 2017). This tool provides both visual and quantitative analyses of behavioral phenomena and their relationship to environmental manipulations (Pennypacker, Gutierrez, & Lindsley, 2003).

Timely and Effective Data-Based Decisions

Those who implement PT use the SCC specifically for the purpose of facilitating effective decision making. Several types of analyses can inform decisions, including, but not limited to, within- and between-session analyses and within- and between-condition analyses. The standardized nature of the SCC provides consistent visual analysis, and the construction of the SCC offers researchers and practitioners powerful metrics for evaluating the effectiveness of interventions with frequency, celeration, and bounce. For more on the quantitative analyses available to precision teachers via the SCC, see Pennypacker et al. (2003).

Most PT models have the charter (e.g., student, behavior technician, coach) placing data points directly on the SCC moments after an observation period ends. This process joins data recording, charting, and analysis in one instantaneous step, which allows for swift decision making. Developments in software technology in recent years have also enabled more immediate quantitative analyses, further facilitating advanced decision making. In PT, the charter can make decisions within a session, and managers and advisers can make decisions daily to weekly. The PT system has someone examining the charted data after every measurement and making a data-based decision, even if one makes a simple decision such as stopping for the day, taking a break, or continuing.

Charts showing frequent condition changes epitomize PT. Haring, White, and Neely (2019) assert that PT is "not a complacent system you can put in place and forget . . . learners change, conditions change, you must change, possibly quite often, to keep up" (p. x). As such, both timeliness and flexibility of decision making deserve consideration when evaluating systems for their alignment with PT. Nonexamples lacking this critical feature include instances where data show no improvement for several weeks without any indication of changes made, or instances where precision teachers make changes to move a learner forward in a set curriculum without any attention to how the learner has responded to the current lesson or activity.

Table 4 Concept Analysis of Precision Teaching

Concept Analysis	
Critical Features	
CF 1. Accelerating behavioral repertoires	
CF 2. Precise behavior definitions	
CF 3. Continuous observation	
CF 4. Dimensional measurement	
CF 5. Standard celeration chart	
CF 6. Timely and effective data-based decisions	
Variable Features	
VF 1. Dimensional quality	VF 6. Decision maker
a. Frequency	a. Performer
b. Latency	b. Charter
c. Duration	c. Chart manager
d. Interresponse time	d. Advisor
VF 2. Degree of restriction	e. Supervisor
a. Unrestricted paradigm	VF 7. Counting time
b. Restricted paradigm	a. Fixed
VF 3. Type of intervention	b. Variable
a. Frequency building	VF 8. Domain
b. Stimulus fading	a. Education and teaching
c. Endurance shaping	b. Personnel training
d. Other	c. The treatment of autism
VF 4. Data collector	d. Sports and fitness
a. Self-monitored	e. Music instruction
b. Teacher-monitored	f. Other
c. Peer-monitored	VF 9. Behavior pinpointed
d. Automatic recording	a. Tool (element)
VF 5. Measurement recurrence	b. Component (simple compound)
a. Timings	c. Composite (complex compound)
b. Daily	
c. Weekly	
d. Monthly	
e. Yearly	

Variable Features

Variable features represent those features that may be present within examples of the concept but do not define the concept (e.g., the color of the object does not define the shape; the color may vary). Those implementing PT can vary a number of features of the system. Many associate the following features with PT, but these features do not define the system. See Table 4 for a features analysis of the updated definition of PT. Table 5 provides examples of PT based on the presence of all critical features identified in our analysis across the variable features. Table 6 provides nonexamples of PT, each missing one critical feature, which possess several of the variable features, described in what follows.

Dimensional Quality

The PT system accommodates all direct measures of dimensional qualities of behavior, specifically frequency (i.e., rate of response), latency, duration, and interresponse time. The specific dimensional quality selected for measurement can vary across PT examples. We strongly encourage the selection of frequency as a measure for the vast majority of pinpoints. PT has a rich history of conference presentations and peer-reviewed literature with frequency as the primary datum. Some researchers have labeled frequency as a measure of performance as one of the guiding principles of PT (Kubina & Lin, 2008; Kubina, Morrison, & Lee, 2002; West et al., 1990). Frequency is a sensitive, universal, and direct record of behavior, linked to the probability of future performance, and closely tied to several major discoveries (i.e., schedules of reinforcement) in behavior analysis and PT (Lindsley, 1992; Vargas, 2009). Examples of measuring frequency include counting compliments given, free throws made, and words written in a multiparagraph essay, each in a given time period.

The problem to solve, question to answer, skill to teach, or stage of learning may necessitate a focus on other dimensional qualities of behavior beyond frequency. For example, a classroom teacher noticing that a student hesitates during the activity of tooth brushing might decide to teach a self-prompting

Table 5 Examples of Precision Teaching

Example	Features Analysis
A professional football player works with a team of experts who help break down the skill sets he wants to improve into component skills with frequency aims. He practices his pinpoints daily, reviews video of his performance, and charts how many of each movement he completed successfully in a fixed timing. He analyzes his progress on the SCC with these experts every few days, and they make recommendations for changes based on the data. His performance in practice improves as a result, and his coach announces he has earned more play time in the next game.	Critical features: 1, 2, 3, 4, 5, 6 Variable features: 1a, 2a, 3a, 4a, 5b, 6c, 7a, 8d, 9b
A piano teacher uses the SCC to chart the notes played correctly for each of the songs taught to a student. The teacher's goal is for the student's progress to follow a x1.4 celeration or above for all of the songs. If any of the charts show slower progress, the teacher spends extra time working on those songs during the lessons and assigns targeted activities for the student to practice when not in lessons.	Critical features: 1, 2, 3, 4, 5, 6 Variable features: 1a, 2a, 3d, 4b, 5c, 6c, 7b, 8e, 9c
An interdisciplinary team works with a young learner with autism who has been engaging in disruptive behavior during teaching sessions. The team begins by pinpointing the challenging behavior: hear-do swipes materials off the table when asked to "give me" an item. They then conduct a component analysis of the receptive identification task and determine that responding appropriately to a "give me" instruction requires fluency on the tool skills of reach, grasp, place, and release. They pinpoint and target these in isolation for a while, using the SCC within and across sessions to analyze progress and make decisions. Once they meet a few frequency aims on these skills in variable timings (10 movements in a row), they shift to 15-s timings and then to 30-s timings. When they return to the original receptive identification program just 2 weeks later, they observe quicker acquisition of targets and a deceleration of the challenging behavior.	Critical features: 1, 2, 3, 4, 5, 6 Variable features: 1a, 2b, 3a, 4b, 5a, 6c, 7b, 8c, 9a
A teenage girl with mild depressive symptoms collects daily data on the frequency of the pinpoint (thinks positive thought about self) and on the latency of the pinpoint (hear-do steps feet on the floor after alarm). She sets aims for where she wants to be with each of these pinpoints. She comes up with her own interventions based on her hypotheses about what might work, and she uses the SCC to evaluate the effects of each new thing she tries. When she meets with her therapist, they review her charts and decide what to do next.	Critical features: 1, 2, 3, 4, 5, 6 Variable Features: 1a–b, 2a, 3d, 4a, 5b, 6a, 7a, 8f, 9b
A job coach works with an adult who has struggled to get a job. After discussing some of the things that had previously gone wrong in the application process and interviews, she creates a road map of skills to develop for better interviewing. During her weekly sessions with her client, they work together on the following pinpoints in fixed timings, which they chart on the SCC and discuss together: (a) free-says reason to hire me, (b) free-says skill I possess for the job, and (c) free-do folds hands during a mock interview. Based on the charted frequency and duration data, they make decisions about next steps, and the coach assigns "homework" to her client related to uncovering more about himself that might be good to mention during a job interview.	Critical features: 1, 2, 3, 4, 5, 6 Variable features: 1c, 2a, 3d, 4b, 5c, 6c, 7a, 8f, 9b

strategy and measure the latency of each response to see if the student struggles with specific steps in the task analysis. A writing teacher may decide to measure duration to see if repeated practice in writing persuasive compositions results in shorter and shorter durations, demonstrating efficiency. In a situation where a learner has learned a new functional communicative response to gain access to attention, but is requesting for attention too often, a precision teacher may look at measuring and programming to increase interresponse times.

Degree of Restriction

Whether teaching, practicing, or assessing learner behavior, an analyst may modify conditions to shape or analyze different features of the behavior. These conditions directly affect the degree of restriction on operant behavior. Unrestricted, or free operant, environmental arrangements allow learners to engage freely without imposed limits to response opportunities. Restricted operants (also referred to as controlled operants; Lindsley, 1996) result from environmental factors

Table 6 Nonexamples of Precision Teaching

Nonexample	Features Analysis
A group of precision teachers has created an online group where they share SCCs displaying the number of tests administered in various regions during the COVID-19 global pandemic. They update their charts weekly, analyze current trends, and discuss their future predictions about how the infection rate may be affected by policy changes, population characteristics, and availability of supplies.	Critical features present: 2, 3, 4, 5, 6 Critical feature missing: 1 (accelerating behavioral repertoires)
An autism interventionist uses the SCC with learners on the autism spectrum. For one of the learners, the interventionist collects daily data on duration of on-task behavior, as well as duration of noncompliance. The interventionist charts these data at the end of each 2-hr session and immediately analyzes celeration, level, and bounce to make decisions about what to do next.	Critical features present: 1, 3, 4, 5, 6 Critical feature missing: 2 (precise behavior definitions)
A classroom teacher collects daily momentary time sampling data for a student to estimate the frequency of the following pinpoint: hear-say answers question during group instruction. The teacher picks up an SCC and charts the frequency of behavior based on observations at the end of a 1-min interval—thus a variation of momentary time sampling. To do this, the teacher uses the 10-min class period as the counting time and charts the frequency based on each 1-min interval in which the behavior occurred, with a ceiling of one per minute and a record floor of 0.1 per minute. The teacher looks at the chart daily and tries to make adjustments to interventions accordingly, using a variety of interventions throughout the first month of targeting this behavior.	Critical features present: 1, 2, 4, 5, 6 Critical feature missing: 3 (continuous observation)
A graduate student has been practicing Say All Fast Minute Everyday Shuffled (SAFMEDS) for class. Every day, the student goes through the cards in 1-min timings and does extra practice or review in between timings. For each timing, the student counts how many terms said correctly, out of the total cards the student got through within the timing. The student converts this to percentage correct, then puts this number (e.g., 85) on the daily per day SCC, where each number on the *y*-axis represents the percentage score. The student uses these charted data to make decisions about whether to do more practice the next day.	Critical features present: 1, 2, 3, 5, 6 Critical feature missing: 4 (dimensional measurement)
A sales consultant works with a team of professionals preparing to sell a new product. They have identified a handful of pinpoints (e.g., free-say lists features of the product, hear-says differences between their company's product vs. a competitor's) to address. They conduct a brief workshop where they deliver instruction via mathetics on the new product. After the workshop, the sales team works in dyads to implement frequency building on their pinpoints several times per week. They collect data on each other's performance in 1-min timings and submit a spreadsheet with their best scores each week. The sales consultant reviews transcripts from sales calls to determine whether increased sales knowledge has resulted in better dialogue on calls with prospects. The CEO of the company reviews monthly sales of the product to see if their investment in this training has produced positive outcomes for the company.	Critical features present: 1, 2, 3, 4, 6 Critical feature missing: 5 (standard celeration chart)
A team of behavior analysts have recently adopted the SCC in their clinical practice. For one of their clients whom they see several times per week, they collect frequency data via a count-up procedure on the following pinpoint: see-do completes step to balance a budget. They use a variety of interventions including modeling, discrete-trial teaching, and differential reinforcement. A behavior technician collects the data sheets at the end of each week and charts them on the daily per minute SCC. The behavior analysts review the data in their monthly case reviews and make decisions regarding this client's treatment plan.	Critical features present: 1, 2, 3, 4, 5 Critical feature missing: 6 (timely and effective data-based decisions)

in which the learner cannot control the number or pace of stimulus presentations. The degree of restriction can vary in the PT system.

Free operant arrangements share the spotlight with frequency as a measure in many of the discoveries made in behavior analysis, such as schedules of reinforcement (Ferster & Skinner, 1957), independence of behavior (All, 1977; Calkin, 1981; Duncan, 1971), and fluency (Haughton, 1972, 1974). These two elements (i.e., free operant arrangements and frequency as a measure) go hand in hand, which explains their coexistence in a majority of PT examples (Lindsley, 1996). Precision teachers generally strive for free operant arrangements, but they make exceptions when it serves learning outcomes (Johnson & Street, 2014).

Degree of restriction operates on a continuum, as the previously noted example of a student learning to self-prompt through a tooth-brushing task analysis illustrates. While teaching this repertoire, the therapist models how the student should prompt. The therapist may choose to measure the frequency of steps completed while still providing the prompts, an example of a restricted paradigm. As the therapist fades prompting, eventually requesting that the learner self-prompt, the therapist moves the learning into more of a free operant paradigm.

Type of Intervention

The specific type of intervention deployed to change behavior does not define the PT system. Precision teachers achieve learning success through precise measurement, frequent analysis, and the flexibility to make changes when appropriate. Precise measurement sets the stage for pragmatic analysis, which leads to flexible, creative, and outcome-oriented teaching and intervention approaches. Effective precision teachers engage in Dewey's (2009) process of reflective thinking (Johnson et al., 2020), by which the scientific method is brought to bear on any problem that presents. After every measurement, precision teachers examine the data. Sometimes, precision measurement indicates the presence of a problem. It does not specify the nature of the problem or the solution. For that, precision teachers must explore and analyze the performance. They observe the performance, looking to identify the variables that might be controlling the flawed performance. They then develop a working hypothesis of the problem and construct an intervention based on the nature of the problem. Further, they test the intervention, making sure to observe carefully. If not successful, precision teachers go back to the drawing board, developing another working hypothesis based on both observations.

In this way, PT is inductive, recursive, and pragmatic. Practitioners can apply a wide variety of teaching methods or intervention procedures to this system. The specific teaching method or intervention procedure does not matter nearly as much as the rationale for the development and selection of the procedure. Precision teachers select interventions based on the nature of the problem with the individual learner's performance, rather than on the intervention's popularity or historical success with another learner. PT critically involves problem solving to find what works. To ensure success, we recommend starting with evidence-based interventions and making appropriate modifications based on each learner's response to the intervention in place, as evidenced by the learner's charted data.

One commonly used intervention is frequency building, an intervention involving timed repetition of a behavior combined with immediate performance feedback (Kubina, 2019). At the time of this article's publication, more than 35 peer-reviewed studies have shown learning benefits related to frequency-building interventions (Kubina, 2019). Precision teachers have contributed a great deal to this body of literature, especially with respect to defining and measuring behavioral fluency and its outcomes (Binder, 1993, 1996; Fabrizio & Moors, 2003; Haughton 1971, 1972, 1980; Johnson & Layng, 1992, 1994, 1996; Johnson & Street, 2004, 2013; Johnson et al., 2020; Starlin, 1971a). We encourage the exploration of frequency building as a potential intervention when implementing the PT system, but we also aim to clarify the distinction between frequency building and PT. These two often-conflated terms are closely linked, but they do not describe the same process and do not always coexist.

Although frequency building is commonly used, the authors want to stress that it is just one of many possible types of interventions that can be employed with PT. Common frequency-building interventions include reducing the number of stimuli to which a learner must respond, and restricting the stimuli in a component skill to match the learner's fluency with a related tool skill. As an example of the latter, an elementary math teacher might modify a "see-write subtraction of multidigit numbers" exercise to only include math facts in which the student had previously demonstrated fluency. Without the additional time required to solve the embedded math facts that the student was not fluent in, the student directs his or her focus to only the steps of the algorithm; increased frequency should follow.

Another common category of intervention is stimulus fading, which can lend itself to creative interventions. For example, the third author consulted with a behavior analyst on designing an intervention for a child with autism spectrum disorder who routinely formed an uppercase letter *P* so that it looked more like an uppercase letter *D*. Teachers used several unsuccessful interventions to teach the student to keep the top half-circle of the letter *P* above the midline, so a creative stimulus-fading intervention was developed. Beneath the midline, and to the right of the vertical line in the letter *P*, the therapist drew a red box and told the student that it was a pool of lava. The imaginative student immediately recognized the importance of keeping the top half-circle out of the fiery obstruction. After several correctly written uppercase *P*s, the pool of lava was turned into a clear box full of poisonous air, followed by an invisible trap door, leading to both accuracy and increased frequencies.

Precision teachers have also used endurance shaping as an intervention, wherein they systematically increase the duration of an activity while maintaining the frequency. For example, after establishing a desired frequency of passes received on a player's backhand during a 20-s measurement, a high school hockey coach could increase the timing length in intervals of 10 s until the player maintains the desired frequency for 1 min.

The range of other types of interventions is quite large. Examples include altering the putative reinforcement contingencies for achieving one's goal, offering new instruction, or modifying the physical environment. We once put an intervention in place where the supervisor simply sat on the corner of a student's desk during handwriting exercises to dramatically increase handwriting frequency. The reason? A wobbly old desk.

Data Collector

The person or apparatus that observes, records, and charts data can vary in PT, depending on the setting, learner population, and availability of technology. Technicians or analysts can collect data on learner behavior, but in many cases, peers or learners themselves can execute this part of the process. As technology evolves, expanding possibilities will arise for automatic recording.

Students can monitor their own performance, either through careful attention to their own repertoires, or via the assistance of video-recording technologies. In many cases, teachers monitor timings, but others, too, can monitor the performance of a learner, including a tutor, therapist, parent, or anyone else delivering services. In school, higher education, or professional environments, a larger number of learners often comprise a classroom, making it impossible for the teacher, professor, or trainer to monitor everyone's performance. In these contexts, precision teachers have used peer-monitoring quite successfully. Monitoring can even be done by computer programs. During parts of the Headsprout Early Reading Program, students practice quickly discriminating specific sounds, which the program then measures with a computer algorithm.

Measurement Recurrence

The measurement recurrence, which refers to how often someone collects and charts data, can also vary in PT. The family of SCCs accommodates daily, weekly, monthly, and yearly views of behavior. In addition, Lindsley designed the timings chart specifically to display multiple successive timed measurements within a day (Johnson & Street, 2014). A vast majority of precision teachers use the daily chart, as daily monitoring has shown many advantages over periodic monitoring (Binder & Watkins, 1990; Maloney, 1998; West et al., 1990; White, 1986). However, measurement recurrence varies based on the pinpoint, intervention intensity, observer availability, and a host of other factors. Kubina (2019) listed options for assessment and intervention schedules that one may consider using to accommodate these factors. The Morningside Multi-Level System of Assessment organizes measurement recurrence into three levels—micro (daily), meta (weekly and monthly), and macro (yearly)—and connects these three assessment types to their respective purpose in a complete program (Malmquist, 2004). As a general rule, one should collect and chart data as often as possible to facilitate timely decision making.

To illustrate, take, for example, an elementary reading class where all four variable features can be observed. While practicing "see-say multisyllabic nonsense words," students chart each frequency measurement (timing) on the timings chart, analyze the new trend, and make an appropriate decision. At the end of the period, the teacher circulates and records the students' best timing, the measurement with the highest frequency, and charts it only on the daily chart. The school psychologist intermittently conducts one-on-one curriculum-based measurements with each student, evaluating the emergence of a related component performance, see-say grade-level passages (i.e., oral reading fluency). At the beginning of the year, staff measure students' oral reading fluency and compare those scores to normative data. Students who are deemed "at risk" have their oral reading fluency assessed every other week, in order to hasten teacher decision making. Teachers chart those data on the weekly chart. Teachers assess the remaining students once a month, thus they use a monthly chart to track their oral reading fluency data.

Decision Maker

Just as the data collector can vary across examples of PT, so can the decision maker. The immediate availability of charted data, combined with multiple chart options for viewing behavior change over time (e.g., the daily per minute chart shows daily data and provides a weekly view of behavior change, the monthly per month chart shows monthly data and offers a half-yearly view of behavior change), allows for multiple levels of analysis. As an example, learners, peer coaches, and technicians can make within-session decisions using the timings chart (Johnson & Street, 2013). With this tool, chart managers can make moment-to-moment decisions about whether to continue practicing a skill or stop for the day, deliver a reward or offer another form of feedback, or try teaching in a different way. In addition, one can document these minor changes and analyze their effects on performance.

With these data on an SCC (typically the daily per minute chart), advisers and supervisors can conduct further analyses using basic and advanced metrics (Pennypacker et al., 2003). At this point, decision making may involve larger programmatic decisions (White, 1985, 1990). Depending on the setting, personnel competencies, and organizational structure, one decision maker can be responsible for any or all of these analyses and subsequent decisions.

Precision teachers often implement decision-making structures that engage and recruit learners in decisions. PT was initially conceptualized as a system of measuring learning and human behavior that broke from traditional ideas of the teacher–student dynamic (Lindsley, 1990). Students took charge of their own learning, with the teacher helping to manage and guide that learning. PT does not represent a top-down, didactic approach, but instead an inductive approach, engaged in by a solitary learner, or as a partnership between two learners, a learner and a mentor, and so on. Due to this history, many modern applications of PT reflect this striving toward an increasingly horizontal relationship between teacher and student.

As an example, let us consider an undergraduate psychology course using SAFMEDS to learn basic terms and definitions, a well-established application of PT (Adams, Cihon, Urbina, & Goodhue, 2018; Cihon, Sturtz, and Eshleman, 2012; Cihon, Kieta, & Glenn, 2018; Urbina, Cihon, and Baltazar, 2019). Students work in dyads, where they time each other's performance, under the coaching of a circulating teaching assistant. After each measurement, a student looks at the picture that their data create and decides that they should continue doing timings in order to achieve an established intermediate aim (daily goal). Conversely, the student's partner might be perturbed by the trend and decide to ask for help. The teaching assistant comes over, evaluates the data, and makes the decision that the learner should keep trying without any changes to see if he or she can improve, an example of a chart manager making decisions.

Counting Time

When observing behavior, one can observe continuously for as long as an entire day or as short as a few seconds. This represents a variable feature within the PT system that depends greatly on the behavior of interest and its context. For behaviors occurring throughout the day, selecting an appropriate observation time requires consideration of the resources available to ensure continuous observation, as well as the likelihood that a behavior will occur within certain windows of time. For example, observing and measuring a pinpoint related to positive interactions with peers may prove much more fruitful during recess or in social groups than in contexts and situations where the behavior is not likely to occur (e.g., nap time, silent reading).

Within a frequency-building paradigm, precision teachers select counting times based on a variety of factors, from total response opportunities based on stimuli, to the difficulty of a task and the learner's history with the task (Binder, 1996; Binder, Haughton, & Van Eyk, 1990). For example, a precision teacher may select a 15-s timing period when working on the motor skill of pinching, because realistically a learner would not be expected to continuously pinch an object at a high frequency for longer than 15 s.

Another layer to this is the option to select fixed counting times versus variable counting times. For example, when assessing the pinpoint "see-say reads word in passage," choosing a fixed counting time would include consistent assessment with 1-min timings, whereas a variable counting time would be the result of allowing the timer to run until the learner completes the passage. The count per minute SCC allows this flexibility because all count per time data are converted to count per minute, and thus analysts can compare frequencies even with varied counting times. This same feature allows for the comparison of frequency data from a complete observation from a 6-hr school day and frequency data from an abbreviated observation of part of a day.

Domain

The domain of application can vary widely in examples of PT. Precision teachers may work with young learners, adult learners, or nonhuman learners. They may use PT with athletes, musicians, public speakers, engineers, medical professionals, or sales professionals. PT implementation may occur in a classroom setting with multiple students, or in a one-on-one therapeutic setting. One may further use the system in an office, a factory, a social work setting, or a government agency. These represent just a few examples of the potentially infinite possibilities where behavior can accelerate with the help of a powerful measurement and decision-making system such as PT.

Behavior Pinpointed

Individuals have successfully applied the PT system to many behaviors, including, but not limited to, academic skills (Fabrizio & Moors, 2003; Johnson & Street, 2013), motor skills (Fabrizio, Schirmer, King, Diakite, & Stovel, 2007; Twarek, Cihon, & Eshleman, 2010), inner behaviors (i.e., private events; Calkin, 2009), sports and fitness performance (McGreevy, 1984), rehabilitation from traumatic brain injuries (Chapman, Ewing, & Mozzoni, 2005; Kubina, Aho, Mozzoni, & Malanga, 1998; Merbitz, Miller, & Merbitz, 2003), and replacements to maladaptive behaviors (Duncan, 1969). As long as pinpoints are selected for the purpose of accelerating repertoires, then they are welcome in the PT system.

In addition to variation in domain, PT correlates beautifully with an approach to curriculum and instructional design that utilizes a hierarchical organization of skills (Haughton, 1972, 1980; Johnson & Street, 2004). Often referred to as component-composite analysis, or element-compound analysis, this way of categorizing related skills breaks down complex skills into their component parts. A common practice in PT involves frequency building on the most basic, fundamental skills, and periodic checks on the more complex tasks that require them (Johnson & Street, 2013). Precision teachers discovered early on that achieving fluency in smaller elements of a skill makes learning a more complex skill easier (Haughton, 1972; Starlin, 1971a, 1971b). Measurement recurrence, chart type, instructional and practice procedures, and decision rules all depend on a learner's current repertoire in relation to an overall goal and where a selected pinpoint may fall within a relative hierarchy of skills.

For example, the aspiring big-wave surfer must first learn how to paddle out past the breaks before he or she can properly "shred their first barrel." A PT surfing coach would begin by measuring the development of relevant tool skills, such as the latency of getting into the proper prone position (i.e., lying face down on the board) and the endurance of maintaining that position. With the body position fluent, the coach would measure the frequency of the component skill: correct paddling strokes in a variety of water conditions. Finally, in order to have a chance at riding the "gnarliest" of breaks, the coach would teach and measure the composite skills of duck diving (plunging the board through the unbroken wave) and turtle rolling (rolling so that the board is positioned above the surfer while diving through the unbroken wave). With each paddling pinpoint fluent, the coach feels ready to teach and measure a whole new set of pinpoints necessary for the surfer to drop in on a radical wave.

Synthesized Steps of PT

Although the aforementioned concept analysis describes each of the elements of PT, it does not fully describe the *process* of PT. The sequence of steps to successfully implement PT holds equal importance and deserves an update. Table 7 presents common steps of PT prescribed by major contributors to the field. The present authors set out to update these steps to match the synthesized definition and concept analysis to thoroughly communicate the process we have observed to be most successful in practice. We propose five steps that encompass the critical features of PT, as well as the key elements present in the previous versions of the steps: (a) pinpoint, (b) arrange instruction or practice, (c) chart, (d) decide, and (e) try, try again. A description of each step is presented in the following sections.

Pinpoint

The first step of PT is to pinpoint behavior to measure and observe. One cannot engage in the other activities in the PT system without first specifying a clear, measurable dependent variable through the pinpointing process. This process typically starts with observation of current performance and/or assessment of a few behaviors within a relevant repertoire. Pinpoints may come from a prescribed scope and sequence within a curriculum, a task analysis, a component-composite analysis, or they may be generated by the precision teacher based on other learner-specific needs (Kubina, 2019; Moors Lipshin, Weisenburgh-Snyder, & Robbins, 2010). From any of these sources, a precision teacher selects a specific behavior or a set of behaviors to target and measure, then modifies the language to create a pinpoint or set of pinpoints. Throughout the process of developing a pinpoint, precision teachers think ahead to how they will measure the pinpoint. Thus, a pinpoint is complete when it lends itself to continuous observation and dimensional measurement.

At this stage, precision teachers typically prescribe an aim for the pinpoint. An aim allows the teacher and learner to see where they need to go. It specifies the terminal goal for the skill being taught. Most commonly, precision teachers prescribe a frequency aim. The frequency aim specifies the range of frequencies of the pinpointed response that have historically predicted outcomes associated with fluency (Fabrizio & Moors, 2003). For example, Fabrizio and Moors (2003) suggested a frequency aim ranging from 60 to 40 words per min for pinpoints resembling "hear-say repeats word." A variety of frequency aims exist from empirical validation with thousands of learners and charts. See Johnson and Street (2013), Fabrizio and Moors (2003), and Kubina and Yurich (2012) for examples of empirically validated frequency aims.

Arrange Instruction or Practice

As described earlier, PT does not prescribe how or what to teach; however, learning must still occur through environmental arrangement. Precision teachers put careful thought into designing effective instructional and practice materials and procedures that lend themselves to high accuracy, high rates of responding, and sensitive measurement.

To establish a skill, a precision teacher may arrange instructional episodes across the continuum of unrestricted to restricted paradigms. In an unrestricted paradigm, the goal is to allow learners to engage in as many responses as they can within a timing period. The most appropriate materials for this arrangement provide continuous response opportunities where the learner can control the pace, the teacher can count responses throughout the timing, and feedback can occur within the timing or after it concludes. In an example, McGreevy (1980) worked on "see-says word" with an 18-year-old boy

Table 7 Common Steps of Precision Teaching

Steps	Author(s)
1. Specify a learning objective or pinpoint. 2. Arrange materials and procedures for learning and practicing the pinpoint. 3. Time the learner's performance and count its frequency. 4. Chart the learner's performance. 5. Review performance trends on the chart. 6. Make decisions about the interventions as needed to improve its growth in frequency and celeration.	Johnson and Street (2014)
1. Pinpoint. 2. Record. 3. Change. 4. Try again.	Kubina and Yurich (2012)
1. Pinpoint. 2. Chart. 3. Change. 4. Try, try again.	Lindsley (1972)
1. Select a task (pinpoint). 2. Set an aim. 3. Count and teach. 4. Develop a learning picture. 5. Decide what to do.	McGreevy (1983)
1. Pinpoint. 2. Count. 3. Chart. 4. Evaluate. 5. Get help.	White (1986)

with moderate cognitive impairments. The learner was encouraged to say as many words as he could, both correct and incorrect. Following an incorrect response, the teacher would provide corrective feedback in the form of saying the correct word, which the learner would repeat. Immediately after this exchange, a new word was presented to keep pace with the learner's natural rate of responding. In this type of instructional episode, it is common for incorrect responses to be higher than correct responses during initial instruction and for the SCC to display a "crossover" pattern (All, 1977), where corrects cross over the errors as accuracy improves.

In a more restricted paradigm, the teacher controls the pace to focus on building accuracy first. Examples of commonly used instructional technologies for this teaching paradigm include mathetics (Gilbert, 1962a, 1962b), direct instruction (Engelmann, 2008), and discrete-trial teaching (Nopprapun & Holloway, 2014). Data on the SCC for this type of instruction may display low frequencies of errors and steadily increasing frequencies of correct responses, showing how the teacher systematically reduces the level of restriction as the learner begins to perform the skill more independently. Some precision teachers choose to chart data during initial instruction, whereas others wait to use the SCC until the transition from an acquisition (i.e., accuracy building) stage to a practice (i.e., frequency building) stage of learning.

Practice plays a key role in establishing fluent repertoires, which is a common goal of precision teachers. Precision teachers arrange for practice activities by using frequency as the primary datum, presenting ample practice opportunities, and focusing practice on building tool and component skills. Appropriate materials for this arrangement include those designed to give a learner more opportunities to respond than they would realistically complete before the end of the timing period. As an example, a learner may practice a math facts worksheet with 100 problems on it with a frequency aim of 70 to 60 facts per minute. In this scenario, several key features are present: (a) there are more stimuli than the learner can answer given the timed period; (b) the materials are arranged without the need for teacher presentation, which allows the learner to progress through each problem at his or her own speed; and (c) practice focuses on the component skill of math facts, which directly affects performance on many higher level math skills. Practice materials designed in alignment with instructional design principles (e.g., Tiemann & Markle, 1990) have produced notable outcomes (Johnson & Street, 2012; Johnson et al., 2020).

Chart

The current authors combined the steps “measure” and “chart” into one succinct step of “chart.” The rationale behind this combination is twofold. First, charting data entails three components in close temporal proximity: observing the behavior, measuring response classes, and plotting data on the SCC immediately following the observation period. Some authors (Table 7) have done this in previous descriptions of the steps of PT, whereas others have listed them as separate steps. We aim to emphasize the importance of the close proximity of these components by putting them together. Second, the current authors presume that any description of PT should clearly communicate the critical nature of the SCC, but the existing descriptions of the PT process do not all include the word “chart.” For clarity, the proposed updated set of steps includes “chart.”

To arrange for this step, a precision teacher selects an appropriate fixed or variable observation period (i.e., counting time) based on the skill. Fixed timings typically use a countdown procedure, where the period of time is set by the teacher at the start of the observation period. Although many precision teachers use a 1-min timing (e.g., McGreevy, 1980), they have also used shorter timing periods (Twarek et al., 2010) and longer timing periods (Ferris & Fabrizio, 2009). The length of the timing period depends on the nature of the skill. For example, Twarek et al. (2010) found that a 15-s timing period for tool skills (i.e., grasp, place, pull, reach, release) was sufficient for increasing the overall frequencies of those skills, as well as allowing the authors to make adequate decisions about the nature of skill instruction. Variable counting times occur in a few scenarios, most notably when teachers record the length of time it takes learners to complete a task or series of tasks in a count-up procedure. For example, Wertalik and Kubina (2018) measured the performance on task analyses of activities of daily living skills with three adolescents with autism. These researchers started the timer when a learner initiated the first step in the task analysis and stopped when a learner completed the final step, counting steps completed independently.

At the conclusion of the observation period, a precision teacher charts the data on an SCC. When using a paper version of the SCC, the precision teacher may need to calculate per-minute frequencies or use a tool (called a “frequency finder”) to plot data. Most digital versions of the SCC make these conversions on behalf of the charter. The immediacy of charting the data on an SCC allows for quick analysis of changes in the behavior of interest over time.

Decide

Once a precision teacher has charted data, the teacher analyzes the data and makes a decision. This crucial step ensures that the learner has made substantial progress, and if not, a precision teacher will make changes to the conditions in place. Visual and quantitative analyses such as celeration, bounce, and level inform these decisions, which can be summarized in three broad decision categories. First, the teacher can keep going. The data show that the learner is making steady growth in his or her performance and nothing warrants change. Second, the teacher can make a change. The data show that the learner is not making progress and has either stalled in his or her performance, or performance has deteriorated. Third, the teacher can stop the current program. Precision teachers most often make this decision when the learner has met the specified frequency aim and no longer needs to work on this skill—the ultimate goal of instruction. A teacher can also make the decision to stop during daily practice if the allotted practice time has diminished. For an in-depth review of decision making, see Liberty (2019).

Try, Try Again

The last step of PT—try, try again—was included in the current steps to highlight the “heart” of PT, as well as the inductive approach that flows through all aspects of PT. The specific phrase “try, try again” comes from Lindsley (1972), where he described the guiding principle that “the child knows best” in detail. This principle reflects the assumption that learners are performing as best they can, given their current histories and environmental situation. By adopting this viewpoint, precision teachers never default to blaming the learner for lack of progress. Instead, they identify the sources of the barriers and account for them. Precision teachers who involve the learner in decisions throughout the PT process—from selecting pinpoints to generating potential interventions—exemplify the “child knows best” approach to improving the behavior of others. “Try, try again” also refers to the inductive approach PT takes. The steps described previously are in no way linear; they represent a recursive process. For example, if the learner is not progressing on math facts, precision teachers may intervene at the pinpoint step; perhaps they selected the wrong behavior to pinpoint. They choose to build frequencies of “free-writes digits 0–9” as an adjacent pinpoint. As frequencies of “free-writes digits 0–9” begin to grow, so do the frequencies of math facts answered correctly. In essence, this last step in the PT process highlights the persistence of precision teachers in careful observation, reflective thinking, and data-based and learner-centered decision making until the learner has demonstrated success.

Conclusion

Many unanswered questions and exciting research possibilities surround PT. We aim to contribute to a broader interest, understanding, and embracing of PT within behavior analysis, as we have observed countless transformations for learners and practitioners in our respective applications of PT. The definition, features, and process described here came together through an analysis of current and historical practices, nomenclature, and literature. These aspects of a verbal community shift over time, and we fully expect a future need to revisit the simple question, as we have in the current article, "what is precision teaching?"

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All of the procedures performed in this study that involved human participants were conducted according to the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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