Behavioral Fluency: A New Paradigm

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No discussion about contemporary applications of behavioral research to educational technology would be complete without mention of what has come to be called "behavioral fluency" or merely "fluency." This paper:

- traces the origins of fluency-based instruction from Skinner's original research;
- provides an introduction to the term "fluency" as it is being used by a sub-community of trainers and educational technologists today;
- summarizes related research and current-day applications in education and corporate training; and
- discusses some of the "marketing" issues that must be addressed in order for fluency-based educational methods to achieve more widespread application.

From Skinner to Precision Teaching

B. F. Skinner (1976) considered his most important contributions to be use of response rate as the basic measure of behavior and the cumulative response recorder, a tool for moment-to-moment analysis of changes in response rates. Indeed, virtually all the specific discoveries made in the basic research laboratories of Skinner, his students, and colleagues involved single-subject research designs in which experimenters directly measured response rates. Most of the principles and methods derived from an experimental analysis of behavior and subsequently applied in classrooms and training programs, including schedules of reinforcement, extinction, response shaping, stimulus fading and discrimination, were originally derived from experiments in which the primary data were response rate measures.

Ironically, when Skinner built his first teaching machines, and others followed with application of behavioral principles to education and training, rate measures were generally dropped in favor of more conventional percentage correct or accuracy-only assessments. This change presumably occurred because the educational community itself—the culture that those early behavioral educators were attempting to influence—generally evaluates accuracy of response and ignores the precise measurement of time. The only exceptions to this are "performance" skills such as typing or reading, where speed of responding has obvious practical value; or in attempts to reduce the frequency of problem behaviors.

Most of those involved in the early programmed instruction movement, as well as applied behaviorists in general, sought to apply the findings derived from laboratory research to practical problems. In effect, they developed procedures and recipes for effecting specific types of behavioral change, combining known principles of reinforcement and punishment, response shaping, and stimulus control. In the process, they derived additional principles and procedures extending the ramifications of basic research to problems encountered in the analysis and production of verbal behavior and of other more complex response topographies than those generally studied in basic research labs. Over the years, however, applied behavior analysts have used response rate measures with decreasing frequency (Barrett, 1990).

Ogden Lindsley took exception to this approach, first in laboratory research with humans that led to coining the term "behavior therapy" (Lindsley & Skinner, 1954), then with his ground-breaking analysis of retarded behavior (Lindsley, 1964), and finally in the development of Precision Teaching (Lindsley, 1972, 1990). Lindsley insisted on using rate or frequency measures (count per minute) as the basic data for analysis. Beginning in the 1960s, Lindsley and his colleagues formulated the methods of Precision Teaching based on daily measures of students' response rates on a wide variety of classroom tasks. They committed themselves and Precision Teaching to the assumption that Skinner's sensitive measure of behavioral probability would lead to additional important discoveries in the classroom while providing

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a basis for educational decisions by teachers and their students (Binder & Watkins, 1990; Lindsley, 1990). This commitment to response rate measurement set the stage for later discoveries about behavioral fluency by Precision Teaching practitioners.

From Response Rate to Behavioral Fluency

One of the earliest contributors to Precision Teaching was Eric Haughton (1972), who encouraged teachers to use brief daily samples (often one minute in duration) of correct and incorrect academic response rates to make decisions about students' progress. By using Lindsley's Standard Behavior Chart (Pennypacker, Koenig, & Lindsley, 1972) to graph these daily rate measures, teachers and their students analyzed performance and learning for each critical objective in their instructional programs. Using this approach, they began to make discoveries about the relationships between criterion performance rates (called "aims") and subsequent progress through the curriculum (Haughton, 1972; Starlin, 1972). In short, they found that students must achieve certain minimum rates of correct responding on prerequisite skills or knowledge tasks in order to progress smoothly through subsequent applications of those skills and knowledge.

For example, competent adults can write correct answers to single-digit arithmetic problems at rates between about 80 per minute and 110 per minute, with perhaps one or two errors (because they're working very rapidly). Haughton and his associates learned that elementary school students who could perform this skill at a minimum of 50 to 60 per minute correct could move successfully through subsequent steps in the California math curriculum (Haughton, 1972). However, students were not able to reach these performance criteria unless they could accurately write digits and read random digits at a minimum of 100 per minute.

Such findings were at odds with the "behavior modification" paradigm that most applied behaviorists brought to their work in classrooms and training programs. A strictly Skinnerian view of response rate suggests that it is a variable that may be pushed up or down using contingencies of reinforcement. In contrast, Precision Teachers found that students' performances hit "ceilings" imposed by non-fluent prerequisites or component skills, and that reinforcement procedures did not enable the students to break through those ceilings. Only additional practice on the prerequisites or components, and attainment of higher performance rates, allowed students to "lift" the ceilings and achieve fluency on more advanced or composite performances based on now-fluent components. Moreover, as they began to discern relationships between rates of performance and their students' abilities to retain and apply skills and to maintain increasing time on task, Precision Teachers began to view the response rate scale as a kind of "spectrum" on which the quality of performance changes as a function of rate. In other words, response rate or frequency is not "merely" a measure of behavior, it is a dimension or property of behavior with qualitative implications (Lindsley, 1991). This view established a new paradigm, beyond the traditional behavior analysts' use of response rate as a sensitive measure of behavioral probability.

From these discoveries, early Precision Teachers derived the instructional principle that in order to acquire and smoothly attain competence on a given composite skill or knowledge task, one must achieve both accuracy *and* speed on its components or prerequisites. Subsequent classroom experience and research by hundreds of Precision Teachers, very little of which was recorded in the professional literature, confirmed that this principle applies to skill sequences across a broad range of curriculum areas at every level (Lindsley, 1990). By adding an explicit time component to the definition of mastery, Precision Teaching formulated a technical definition of fluency as accuracy plus speed, or quality plus pace (Binder, 1988, 1990a). This represented a significant advance beyond the traditional approach of gating progress through curriculum hierarchies by means of accuracy-only criteria or absence/presence checklists. Now students worked to achieve fluency criteria at each step in a curriculum before moving on. As we shall see, these discoveries by Precision Teachers were consistent with findings in other fields, including more basic academic research on the learning process.

Outcomes Associated with Fluency

Evidence from the practice of Precision Teaching and from research in other fields suggests that behavioral fluency is associated with three general categories of outcomes:

- retention and maintenance of skills and knowledge;
- endurance or resistance to distraction; and
- application or transfer of training.

These findings correspond, as well, to our intuitive understanding of mastery and its effects: we recognize that those skills which we can perform accurately and without any hesitation are also those that we will retain over long periods of time, will be able to use in relatively distracting or taxing situations, and will more easily be able to apply in learning new more complex skills and knowledge

Both Precision Teachers and others have investigated the effects on these critical learning outcomes of achieving fluent or non-hesitant performance. For example, Orgel (1984) found that students who achieved fluency criteria in university calculus classes retained nearly twice as much, when tested six weeks after completion of the course, compared with those who completed the course using conventional accuracy-only criteria. Verbal learning researchers (Osgood, 1946; Peterson, 1965; Judd & Glaser, 1969) who measured latencies rather than accuracy-only in paired associate verbal learning tasks found that latencies decline after learners attain 100% accuracy. This finding supports the conclusion that continued learning beyond 100% correct, which has been demonstrated in countless experiments to increase retention and transfer of training, can be directly measured in the form of shorter response latencies. This conclusion corresponds to the everyday experience that continued practice of virtually any skill (e.g., foreign languages, martial arts, musical performance) produces more fluent or non-hesitant performance along with better retention, improved resistance to distraction, and greater ability to apply the skill.

Studies of "automaticity" by proponents of information-processing models of memory and cognition also support these conclusions (e.g., Bloom, 1986). For example, LaBerge and Samuels (1974) found that subjects became less distractible when they achieved short latencies, beyond 100% accuracy, in paired associate tasks. Precision Teachers (Binder, Haughton, & Van Eyk, 1990) have found that achieving rapid rates of response on academic and vocational tasks enables students to maintain satisfactory performance levels for longer periods, with less variability, and greater "attention span." Again, these findings are consistent with the casual observation that we can perform fluent or automatic skills with greater subjective ease, more resistance to distraction, and for relatively longer periods of time. Anyone who has learned to use a computer, dance, or play a musical instrument recognizes that the ability to perform for extended periods and to "improvise," or flexibly apply the skill, comes only with fluency.

Fluency and Overlearning

In effect, measuring fluency by using response rates or latencies provides a method for directly assessing the effects of "overlearning." In traditional learning research and instructional practice, where 100% correct is the highest possible performance criterion, the term "overlearning" has a strictly operational or procedural meaning: additional learning opportunities provided beyond the point of 100% accuracy. Within the conventional accuracy-only framework, there is no method for directly measuring the effects of these trials. However, research long ago demonstrated that a given overlearning trial does not produce a predictable amount of learning. For example, Kruger (1929) found that a given number of overlearning trials did not produce the increase in retention that one would expect from calculating the proportional contribution of a single trial to mastery of the 100% correct acquisition criterion (e.g., adding 50% more trials did not improve retention by 50%). Judd and Glaser (1969) found that subjects who met an accuracy criterion more quickly also decreased their latencies after the last error more quickly, suggesting that a given number of overlearning trials cannot be predicted to produce a given amount of performance improvement. Thus, instructional methods that depend on accuracy-only measures cannot confidently predict the need for or amount of performance improvement produced by overlearning trials, even though the effects of these trials can be measured indirectly in subsequent assessments of retention or transfer of training. On the other hand, measures of latency or response rate can provide a means of directly assessing progress toward automaticity, or fluency, beyond the point of 100% accuracy. Use of such measures introduces an entirely new stage of learning—the stage of building fluency—beyond the state of initially acquiring accuracy or correctness. Proponents of fluency-based instruction (Binder, 1987, 1990a; Johnson & Layng, 1992) argue that this stage of learning ought to be included in virtually every type of instructional program, if the desired outcome is true mastery.

Implications for Instructional Design

One of the more obvious ramifications of defining fluency as the desired outcome of instruction is a re-assertion of the importance of *practice* as part of the learning process. In recent years, under the influence of cognitive theorists and structural analyses, so-called "drill and practice" strategies have nearly disappeared from education and training. In part, this trend reflects increased emphasis on complex verbal and problem-solving repertoires and on cognitive or structuralist theories designed to account for acquisition of such behavior. It also may be due to the fact that in the absence of explicit fluency criteria, drill and practice activities can be both boring and seemingly without purpose from the perspective of the learner. Moreover, educational technologists with a behavioristic background may never have subscribed fully to the "law of practice," having replaced it with reliance on schedules of reinforcement and careful use of shaping and fading procedures. Like their cognitivist colleagues, they have tended to under-estimate the importance of practice. Nonetheless, those responsible for teaching skills outside formal academic settings (e.g., teachers of music, dance, foreign languages, crafts, martial arts, athletics) have traditionally recognized the importance of large amounts of practice as a means of creating complex repertoires by building fluency in step-by-step sequences of components and prerequisites. A fluency-based approach merely acknowledges and provides a systematic methodology for implementing effective practice strategies.

Once we acknowledge the importance of fluency, and the relevance of time in specifying mastery criteria, a number of implications for instructional design become apparent. Binder (1977–1983; 1990a) has summarized these implications as factors that prevent or obstruct fluency and those that promote development of fluency, falling into five categories:

- measurement;
- instructional procedures;
- instructional materials;
- skill elements; and
- knowledge elements

Measurement

As already suggested, if we do not include the time dimension in our definition of mastery, we will fail to discriminate between fluent and non-fluent performance. On the other hand, if we incorporate fluency criteria into our instructional programs, we will be able to differentiate between masterful and merely accurate performances, and to develop strategies for remediating deficits.

Instructional Procedures

Once we have begun to measure response rates or latencies, it becomes clear that aspects of conventional instructional procedures actually prevent learners from becoming fluent. The obvious procedural deficit in most programs is that they lack sufficient practice opportunities for attaining fluency. In addition, many procedures prevent learners from moving at their own pace. For example, conventional "trials procedures" and computer-based training programs often require learners to pause for the next frame, thus interrupting the flow of behavior. Programs that emphasize prevention or suppression of errors, always interrupting the flow of behavior with correction and feedback, can also obstruct development of fluency, as can procedures which simply provide fewer response opportunities per minute than occur in fluent, "real-life" performance. This is analogous to interrupting a speaker after each word to reinforce or correct the word, rather than allowing the speaker to complete the sentence before providing feedback. All of these difficulties can be addressed by procedures that allow learners to respond as rapidly as they are able, without interruption, for some period of time. It is also important to understand that because non-fluent performance is susceptible to distraction and interruption of attention, procedures that require learners to practice for relatively long durations prior to reaching fluency can prevent or retard development of fluency. A better approach is to provide repeated brief practice periods to build fluency in a series of "sprints" before extending practice to longer durations (Binder, Haughton, & Van Eyk, 1990; Johnson & Layng, 1993).

Instructional Materials

Instructional materials can prevent fluency by providing too few examples of concepts or operations, by being cumbersome or difficult to use, or by being difficult to read or lacking in ergonomic design features. In fact, ergonomics or human factors engineering, as a discipline, devotes a good deal of attention to designing environments that support fluent performance. Building fluency demands materials that are easy to use and provide a large number of opportunities to respond.

Skill Elements

When critical steps or prerequisites in procedures or chained skills are not fluent, they can prevent development of overall fluent performance. Examples include typing skills as a prerequisite for word processing, re-phrasing objections as a part of responding to difficult questions in a sales situation, or solving simple arithmetic problems as a prerequisite for solving equations. Thus, instructional programs should provide sufficient practice for attaining fluency on critical skill elements (or components) and prerequisites in order to ensure fluency in composite skills.

Knowledge Elements

Prerequisite knowledge that is not "second nature" or fluent can retard development of subsequent skills or knowledge. Witness the failure of most learners at some point in the math curriculum. When basic computational "facts," for example, are accurate but not fluent, there comes a time in the sequence where the student simply cannot keep up with demonstrations of complex problem-solving when provided as a part of instruction in the more complex task. In the absence of fluent discrimination between examples and non-examples of a concept, students will not be able to confidently or fluently use that concept as part of a more complex logical or rule-application sequence. Similarly, reference environments that do not support fluent access to prerequisite information (e.g., hard-to-use computer documentation) can retard or prevent development of fluency in terminal performances.

Fluency-based Education and Training

Both fluency criteria and procedures intended to produce fluency have been core elements of Precision Teaching since the early 1970s (Lindsley, 1990; Binder & Watkins, 1990), and have more recently been introduced into the field of corporate training. Results from three demonstration programs illustrate the instructional power of this approach.

During the early 1970s, the Precision Teaching Project in Great Falls, Montana, added 20 to 30 minutes per day of timed practice, charting, and decision-making in basic skills to an otherwise conventional academic program in the Sacajawea Elementary School. Over a period of three years, the average performance of Sacajawea students on the

Iowa Test of Basic Skills rose between 20 and 41 percentile points (depending on the sub-test), as compared with all of the schools in the district (Beck, 1979; Beck & Clement, 1991). These results, achieved at a cost of a few hundred dollars per teacher for training plus less than ten dollars per student per year for materials, represented a nearly unprecedented level of cost-effectiveness in educational improvement. Submission of these data to the Joint Dissemination Review Panel of the U.S. Office of Education led to funding for dissemination of Precision Teaching throughout the United States for nearly a decade and, indirectly, to the establishment of an annual international conference for practitioners and researchers in the field (Binder, 1991a).

The Morningside Academy (Binder, 1991c; Johnson, 1991; Johnson & Layng, 1992, 1993) has been another major success story in fluency-based instruction. Dr. Kent Johnson began the Academy as a tutoring center in 1980, combining the methods of Precision Teaching with Direct Instruction (Engelmann & Carnine, 1982) a systematic approach to the design of instructional methods and materials. Now, more than a decade later, the Morningside Academy, a full-time school, has produced unprecedented gains in learning among its students, both children and adults. Using teaching programs and materials based on a synthesis of several different approaches to instructional design, the Academy emphasizes establishment and attainment of fluency criteria for each step in its curriculum. Children and adolescents in the program gain an average of almost three grade levels per year, as measured by standardized tests. Its programs in reading, math, writing, and study skills for adult, homeless illiterate students produced an average of two academic years every five weeks in two skill areas, with 6 to 10 hours per week of instruction. These are among the largest gains ever achieved in a program funded by the federal Job Training Partnership Act (JTPA). More recently, Morningside's results have been replicated, and even improved upon, as the program has been implemented at Malcolm X College in Chicago. Although fluency is not the only innovative element of Morningside's program, its developers attribute a major part of their success to fluency-based instruction (Johnson & Layng, 1992, 1993).

Finally, fluency-based instruction is making inroads in the field of corporate training (Binder, 1987, 1990a), establishing a new standard for criterion-referenced instruction. For example, a program designed to teach bankers about complex financial products and services integrated easy-to-access reference and training documentation with exercises in which trainees practiced to attain fluency in speaking about customers' potential needs and bank solutions (Binder & Bloom, 1989). Exercises included practice sheets requiring learners to categorize possible customer needs, timed practice with flashcard-like materials for learning elementary facts and discriminations, rapid recall exercises in which trainees practiced recalling and "blurting out" as many facts about a given topic as possible, and brief presentation practice that enabled trainees to speak confidently, in their own words and at their normal pace, about customers' needs and bank solutions. Each exercise had an explicit fluency standard (e.g., "blurting out" 15–20 correct facts per minute for two minutes on the rapid recall exercises). Once they had attained fluency on these exercises, trainees worked with case study materials to apply what they had learned to complex business situations and to make customer-oriented presentations. In addition, timed multiple-choice pre-test and post-tests provided sensitive measures of tip-of-the-tongue recall of key facts and discriminations. The results of this program were trainees who, according to one manager, "know these products better than I did after five years of selling them." In fact, fluency testing revealed that new trainees were able to respond to key questions and to match solutions with customer needs far more accurately and 2.4 times more quickly than experienced sales people. In the context of face-to-face sales situations, this improvement in response latency has an obvious value; if a salesperson cannot respond to questions and comments without hesitation, then he or she is likely to avoid the topic altogether or to use "relationship skills" to hide a lack of fluent knowledge. One bank executive called the program "a strategic business advantage" because or the obvious fluency with which trainees were able to discuss the bank's products and services, analyze customers' needs, and propose solutions.

Although the preceding examples reflect only a few possible applications of the fluency-based approach, the robust results attest to the potential of applying research about fluency to the development of education and training programs.

Marketing Effective Instruction

As with many forms of effective educational technology, there has been resistance to widespread use of fluency-based instruction. Resistance in the educational establishment probably reflects the general contingencies opposing effective innovation when it is not in line with current educational fads or theories (Watkins, 1988). Emphasis on direct measurement and repeated practice components of the instructional process certainly challenges much of what is now in vogue among mainstream educators. In corporate training, resistance to effective instruction is less widespread, although practice and "behavioral" methods are likewise out of favor among many instructional designers and trainers working in organizations.

Among applied behaviorists, and especially those involved with fluency-based instruction, there have been efforts in recent years to more actively promote effective instructional methods (Binder & Watkins, 1990). In papers devoted to this topic, Binder (1991b, 1993) proposed that so-called "behavioral educators" adopt strategies from private sector sales and marketing to encourage wider application of their methods. These strategies include:

- identifying the perceived needs of specific "market segments" and adapting the technology to address those needs;
- creating and packaging tangible products and programs rather than merely promoting generic methods, concepts, processes, etc.;
- seeking new and emerging markets for specific solutions;
- identifying and focusing on opportunities for greatest instructional impact;
- using plain English, rather than technical jargon, to describe methods and programs;
- approaching the effort strategically, analyzing the contingencies that govern adoption of effective methods and planning accordingly; and
- writing about programs and methods for non-technical publications, addressing the potential consumers of educational programs (parents, business people, the literate public, etc.) rather than or in addition to educators and trainers, showing how effective educational technology can solve their perceived needs and problems.

One of the key recommendations is to separate efforts to "convert" others to the language and conceptual framework of behaviorism from communication about the *effectiveness* of the technology. For example the words "behavioral" and "behaviorism" have, for a variety of reasons, taken on negative connotations with many educators and literate adults. Although we might wish to correct many of the errors and over-simplifications that have led to this situation, such a correction procedure is likely to obscure communication about results when the two efforts are combined. Therefore, we might choose to discuss and promote "measurably effective teaching methods" rather than "behavioral methods" in writing and speaking about the technology. This use of language might increase the likelihood that the technology will be evaluated on its own merits rather than on the basis of philosophical preconceptions or conceptual biases.

Two examples of fluency-based instruction mentioned in the previous section illustrate adherence to some elements of this "marketing" approach. The Morningside Academy was founded, in part, to escape the restrictions on technology development that exist in the public education system. For over a decade it has been a leading-edge educational laboratory, as well as a commercial venture. Focusing on student populations with specific needs (children and adolescents with "learning problems" and adults with literacy and job skills needs), Morningside has created programs that directly and powerfully address those needs. In the process of replicating the program in inner-city Chicago, Johnson and Layng (1992) have communicated directly with parents and community leaders, marshaling tremendous support for their program by demonstrating levels of effectiveness that cannot be ignored. Results at Malcolm X College have led to widespread interest in the Morningside Model and requests for dissemination from both public and private sector institutions.

Efforts to promote fluency as a new standard of mastery in corporate training have been led by Precision Teaching and Management Systems, Inc. (PT/MS), a Boston area consulting and training development firm that markets its trademarked FluencyBuilding™ approach to instructional design and assessment. By articulating a systematic methodology and process for incorporating fluency-based instruction and assessment into corporate training programs, the company is positioning itself to train instructional designers and continue marketing of its fluency-based custom training programs. Because the term "fluency" has plain English appeal as a description of the desired training outcome, it has been relatively easy to "sell" the concept to trainees and line management within corporations (Binder, 1990a) and to attract interest via such organizations as the National Society for Performance and Instruction (Binder, 1990b).

Summary and Conclusion

Practical applications of fluency-based instruction have arisen in training and education as an outgrowth of Precision Teaching which, in turn, traces its origins to Skinner's use of response rate measures in the laboratory. However, corroborating research from other fields of education and psychology, including study of automaticity by cognitive scientists, has enabled proponents of fluency to make a wider appeal, beyond the constituents of strictly "behavioristic" approaches to instruction. Results of fluency-based instructional programs have confirmed the importance of including in instructional systems an explicit stage for building fluency. Some have even argued that national competency standards in academic skills should be based on fluency criteria (Pennypacker & Binder, 1992). Those attempting to gain wider application of fluency-based methods of instruction and assessment have begun to apply principles from private sector sales and marketing. Indeed, incorporation of Skinner's rate measure into instructional programs, along with its implications for instructional design, promises to establish a new paradigm for defining and producing mastery of skills and knowledge. □

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