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THE BEHAVIOR ANALYST TODAY

A Context for Science with a Commitment for Behavior Change

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A continued "special thanks" to C. A. Thomas, for his hard work and dedication to this Journal.

Submission Information:

Most contributions are by invitation and all are then peer-reviewed and edited. The editors, however, welcome unsolicited manuscripts, in which case, we suggest potential authors send an abstract or short summary of contents and we will respond as to our interest in a full manuscript submission. In all cases, manuscripts should be submitted electronically saved in "rich text format"(.rtf) to BOTH Beth Rosenwasser at ibrosie@aol.com and Joe Cautilli at jcautill@astro.temple.edu Please adhere to APA format and use "Times New Roman" font in 11 pt. throughout. In references, however, please italicize the places where APA format would have you underline. Headings are encouraged and must follow APA format.

Our Mission:

The Behavior Analyst Today is committed to increasing the communication between the sub disciples within behavior analysis, such as behavioral assessment, work with various populations, basic and applied research. Through achieving this goal, we hope to see less fractionation and greater cohesion within the field. The Behavior Analyst Today strives to be a high quality journal, which also brings up to the minute information on current developments within the field to those who can benefit from those developments. Founded as a newsletter for master level practitioners in Pennsylvania and those represented in the clinical behavior analysis SIG at ABA and those who comprised the BA SIG at the Association for the Advancement of Behavior Therapy, BAT has evolved to being a primary form of communication between researchers and practitioners, as well as a primary form of communication for those outside behavior analysis. Thus the Behavior Analyst Today will continue to publish original research, reviews of sub disciplines, theoretical and conceptual work, applied research, program descriptions, research in organizations and the community, clinical work, and curriculum developments. In short, we strive to publish all which is behavior analytic. Our vision is to become the voice of the behavioral community.

QUALITY AND COMPREHENSIVE APPLICATIONS OF BEHAVIOR ANALYSIS TO SCHOOLING

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We describe the CABAS® system for developing and maintaining quality in schools that provide a system-wide application of behavior analysis to all of the components of education for teaching the entire curriculum to students. The system has accrued an extensive database for developing and maintaining quality applications. We outline some of those components including: minimal standards of teaching as applied behavior analysis, curricula for teachers and other professionals, research-based tools to train and monitor professionals, curriculum revisions for students occasioned by our research, CABAS® and quality, an overview of the CABAS® system. We also show data display examples from one of our schools in Ireland for children with autism and one of our middle schools for students with behavioral disorders, and the CABAS® approach to monitoring and accrediting CABAS® schools and professionals. Finally, we provide references for our research-based tools for other providers of behavior analytic services.

The basic and applied science of the behavior of the individual has led to improved instructional and therapeutic practices over the last sixty years (Greer, 1997a, 1997b). Increasingly, parents of children with autism have insisted on the scientifically based procedures of applied behavior analysis for their children (O'Brian, 2001). Those of us who have spent our professional lives researching and developing scientifically based services are delighted. Education and therapy have been plagued by fads, fashions, and the pervasive control of pre- scientific contingencies (Greer, 1992). For an increasing number of parents, data based procedures are on at least equal footing with the latest fashion. However, unless the day in and day out applications of the science are precise and reflect the expertise of the science, we will not provide the necessary *quality* for the outcomes predicated by our research and model treatment programs. The long-term survival of good practices will depend on the integrity of applications, and the integrity of the application will determine our capacity to help children.

We suspect that the *quality* of application of research findings varies greatly across settings and providers. Over the last 20 years, our particular systems approach to *education as behavior analysis* has provided a research base for increasing the quality and cost-benefit ratio of applications to education and child behavior therapy. We call our system CABAS® (Comprehensive Application of Behavior Analysis to Schooling). While many of the tactics and strategies are currently accessible in the research literature, other research findings are not yet accessible in published form or are dispersed across a variety of journals. Several papers have summarized the system and described the research base from the first two decades (Greer, 1997a, 1997b); however, those papers have not highlighted tactics that develop and maintain quality. In this paper we take the opportunity to provide a description of a few of the critical procedures for developing, monitoring, and maintaining quality application of behavior analysis. A book-length manuscript with in depth technical descriptions of these and other procedures should be available in a few months (Greer, in press).

Minimal Standards

The minimal and more conspicuous standards of quality applications of behavior analysis are outlined in Table 1. The importance of close continual contact with the moment-to-moment outcomes of applications is evident (Bushell & Baer, 1994). In the beginning there were data, and in the quest for quality, data are even more critical as we shall describe. Visual displays, and how they are used, make the difference between applications that work and those that don't (Greer, McCorkle, & Williams, 1989). As behavior analysts, our applications are individually based, and *require* data in order to be successful. The *kinds* of data and the *quality* of those data are critical to providing the best outcomes for our clients. Our applications are based on what may be characterized as a *science of the behavior of the individual*. The methodology of our science and its practices are driven by the responses of the individual. Few tactics are population derived. Tactics are particular techniques that have been subjected to research in the applied or basic science

Table1. Conspicuous Characteristics of Teaching or Therapy as Applied Behavior Analysis

• All instruction is *individualized* whether the instruction is provided in a one-to-one setting or in groups.	• The *principles* of *the basic science* of the behavior of the individual and the 200 plus *tactics from the research* are used to teach *educationally* and *socially significant repertoires*. Tactics must be fitted to the individual needs of students.
• *Teachers continuously measure* teaching and student responses. Teaching is driven by the moment-to-moment responses of each individual student and existing research findings.	• The classroom or treatment setting is a positive environment-- coercive procedures are avoided and counterproductive.
• *Graphs of the measures of student's performance are used for decisions* about which *scientifically-tested tactics* are best for students at any given instructional decision point.	• Expertise in the science is used to make *moment-to-moment* decisions based on the continuous collection of data, its visual summary in graphs, and the precision of the vocabulary of the science used with the data. Indeed, the data language is part of that science. The precision of the vocabulary of the science drives the production of good outcomes.
• Logically and empirically *tested curricula and curricular sequence*s are used that are repertoires of behavior. The goals of instruction (antecedents, responses, and consequent contingencies within setting events) are *educationally* and *socially significant repertoires.*	• Teachers/practitioners are strategic scientists of pedagogy/therapy and applied behavior analysis because the process of determining what each student needs at any given point requires a strategic scientific analysis.
•	• The progress of students is *always* available for view in the form of up-to-date graphs that summarize all of the students' responses to instruction.

and they are tied to the basic principles of behavior, for the most part. While the principals of the science hold broadly, the specific tactics are idiosyncratic to individuals. Wholesale applications can improve group means, but we teach and do therapy with individuals. Statements such as "we don't need to take data because the research has already been done" are not only inconsistent with our science, they are inconsistent with any system that requires accountability.

Also, it is critical to set *educationally* and *socially significant* objectives, if effective pedagogical practices are to lead to habilitative and educationally important results. This credo of behavior analysis is even more important now than when Baer, Wolf, and Risley proposed it in the first issue in 1968 of the *Journal of Applied Behavior Analysis*, because our science is more powerful and we are asked to make critical interventions in the lives of children. Moreover, we know much more scientifically about how to design curricula than we did then thirty-four years ago (Greer, in press). Today, educators who are behavior analysts can and do educate the *whole child*. That is, behavior analysis is applied to the complete range of instruction from basic academic literacy to complex problem solving routines. But providing the expertise to do so requires sophisticated practitioners and sophisticated means to insure consistency in quality.

A System for Developing and Maintaining Quality

How does one develop, motivate, monitor and maintain professionals who provide these minimal expectations? In a paper published in 1982 for the *Educational Researcher* (a journal of the American Educational Research Association), one of us outlined the potential for such a system (Greer, 1983). In response, Jere Brophy, a leading researcher in teacher education, stated that providing the sophistication called for to provide teaching as behavior analysis wasn't possible for entire schools (Brophy, 1983). In the intervening years, CABAS® has developed over a dozen schools and a research base for how to provide a *system* for entire schools that has provided educational outcomes. These outcomes are at least four to seven times more effective than group directed eclectic approaches to education (Greer, 1997a, Greer, 1997b; Greer et al., 1989; Lamm & Greer, 1992; Selinske, Lodhi & Greer, 1991). The components of the system devoted to the instruction and monitoring of professionals include a curriculum for the education of professionals, a continuous monitoring of system for maintaining quality applications by professionals, and a motivational system.

Education Professionals

Part of our training program builds on Keller's PSI approach (Keller, 1968). That is, the components of behavior analytic teaching, parenting, and supervision are divided into three categories and arranged from less difficult to complex and professionals move through the levels of expertise in an individual fashion. The three broad repertoires of teachers as strategic scientist are (a) the vocabulary of the science or *verbal behavior about the science*, (b) classroom and supervisory practice in-situ or *contingency-shaped repertoires of in class practice*, and *verbally mediated repertoires* (rule-governed, verbally governed, and verbally governing). Instruction in these three repertoires is arranged in levels of difficulty or modules that we tie to teacher ranks (Teacher I, II, and Master Teacher), followed by three behavior analyst ranks, and three research scientist ranks. There are 10 modules for each of the three repertoires and several components in each module. A component in a module is an instructional objective for the professional. For example, in the first teacher rank there are 87 individual criterion referenced-objectives or components in the 30 modules. The ranks, and the modules in each rank, are used as a way to organize professional instruction by levels of difficulty, motivate staff, recognize achievement, and acknowledge expertise for consumers. When individuals in our schools complete the requirements for each rank under the supervision of a senior behavior analyst, those individuals may submit their achievements to the CABAS® Professional Advisory Board for board certification. This board certification extends the basic certification provided by the Association for Behavior Analysis in our schools to *advanced* and *specialized* expertise in teaching and supervision as behavior analysis. Providing criterion-referenced assessments of performance in the three repertoires of teaching as behavior analysis does this. Thus, like the residency in medicine, the CABAS® board certification documents a specialization in teaching and supervision as a strategic science for the professionals in our schools.

A Brief Sketch of the Curricula for Teachers

The modules on the verbal behavior about the science in the Teacher I Rank require mastery of the terms and concepts in texts that are scientifically accurate. These include Cooper, Heron, & Heward's (1987) *Applied Behavior Analysis* text, Malott, Malott, & Trojan's (2000) text, *Elementary Principles of Behavior*, and *Teaching Operations for Verbal Behavior* (2000) (an in-house publication for CABAS® Schools). The candidates also complete introductory texts such as Greer & Dorow's *Specializing Education Behaviorally* (1976), or equivalent introductory texts, before mastering the above texts. The candidate masters scientific descriptions and definitions (as intraverbals from the texts) and in-situ tacts of the tactics and principles at a 90% mastery criterion. In the second rank they master 6 chapters in advanced applications of behavior analysis, including chapters from Catania's (1998) book *Learning*, along with selected chapters in Donahoe & Palmer's (1994) text *Learning and Complex Behavior*, and *Designing Teaching Strategies: A Systems Behavioral Approach* (Greer, in press). In the Master Teacher rank, they master additional chapters in *Designing Teaching Strategies: An Applied Behavior Analysis Systems Approach* (Greer, in press), and Skinner's (1957) *Verbal Behavior* as it applies to pedagogy and curricular design.

In the contingency-shaped or classroom practice modules for Rank I, the candidate acquires in-situ instructional repertoires that show errorless and rapid presentation of learn units (Greer & McDonough, 1999), accurate data collection, accurate data representation, and progressive increases in the numbers and rate of learn units presented. In ranks II and the master teacher ranks, selected verbally mediated repertoires shift to contingency shaped in-situ practices. That is, decision processes that were verbally mediated in early modules become contingency-shaped responding in-situ.

The verbally-mediated modules in the first and second ranks include accurate decisions that are verbally-governed by selecting from the 200 plus tactics in the literature, and the completion of 10 experiments replicating tested tactics in the literature (including scientific presentations). In addition, these modules include the summary of 40 research articles in the literature, and the mastery of 200 tactics from the science as they are applied to analysis of instructional problems. In the Master Teacher Rank, the candidate demonstrates applications with junior professionals, advanced decision analyses, use of observational protocols to train and motivate junior professionals. In addition they learn how to base curriculum design on the basic tenets of Skinner's verbal behavior and behavior selection from research in the *Analysis of Verbal Behavior* journal, and the 28 experiments done on verbal behavior at Columbia University and in CABAS® Schools (Greer and Ross, in press). They are also required to conduct new research. The Assistant, Associate, and Senior Behavior Analyst ranks involve (a) the conduct of systematic and seminal research that serves students and the science, (b) demonstration of in-depth mastery of advanced or new concepts in the science (i.e., the matching law, relational frame theory, stimulus equivalence, interbehaviorism, paradigmatic behaviorism, Watsonian methodological behaviorism, Hullian methodological behaviorism) (c) demonstration of mentorship with junior professionals, and (d) contributions to professional and school communities. The Assistant, Associate, and Senior Research ranks are based strictly on the numbers and quality of research and conceptual publications in the science.

Candidates move through the ranks under the mentorship of senior behavior analysts, professors at the university (for those enrolled in university programs), and master teachers. The criterion of mastery is present for all components. That is, instruction continues until the candidate achieves mastery at each successive level of competence. Components associated with classroom practice are tied to the particular types of students being taught (see Greer, in press, for a description of how this is done). The first rank is typically completed in one or two years. Students who are in our MA program at Columbia University Teachers College typically complete two ranks over a year and one half to two years. Rate of completion is individual and based on competency not hours, although there are extensive in-situ hours of practice involved. The higher the rank achieved by the teacher, the better are teaching outcomes with students (Greer, 1997a).

As the reader has surmised, the instruction of professionals is done using behavior analytic procedures. Moment to moment and long-terms effects of the instruction of staff is driven by the *data* on the *staff member's* performance. Since all professionals collect data and provide accurate visual displays of their students' performance on *all instruction*, the progress of the teacher through ranks is tied always to how well they teach—both in terms of their productivity and quality. In turn, the progress of the staff is monitored and graphed for assessment of the supervising behavior analyst's achievement (i.e., they are the teachers of the teachers).

RESEARCH-BASED TOOLS TO TEACH AND MONITOR PROFESSIONALS

There are several key tools that are used to teach different repertoires and maintain and motivate performance and these tools are derived from our research. Some of these tools include the Teacher Performance/Rate Accuracy Observation Protocol (Ingham & Greer, 1992), use of the learn unit at the student level (Bahadorian, 2000; Greer & McDonough, 1999), supervisor learn units for accurate use of terms (Nuzzola-Gomez, 2002), and the CABAS® Decision Protocol (Greer, in press; Keohane, 1997). Other tools used include accurate supervisor learn units for decision protocol training, the use of comprehensive student measurement (Greer et al., 1989; Selinske et al., 1991), teacher performance measurement, supervisor/administrator performance measurement (Greer et al.; Selinske et al.), and the system-wide summary data (Greer 1997a, 1997b; Greer et al.).

Teacher Performance Rate/Accuracy Performance Protocol (TPRA)

This observation protocol measures the teacher's or therapist's accuracy and rate at presenting learn units to students. Presentations of instructional units that are learn units predict student outcomes—those that are not learn units are not likely to produce new operants for students (see Greer & McDonough, 1999 for a summary of that research). Observations of non-behaviorally trained practitioners show that they produce few learn units (Greer, 1994b). When supervisors use this procedure to train and to monitor instruction or therapy the behavior changes for the clients increase from four to seven times (Ingham & Greer, 1992). If therapist trainers and supervisors use this procedure on a regular basis with students they can dramatically improve the prognosis of the student, whether the student is receiving massed or captured learn units (e.g., incidental learn units). This is a good first effort in training or retraining teachers. It is done in-situ and learn units between the supervisor and the teacher can occur during or after the observation. This procedure affects teacher performance almost immediately and its continued use insures consistent quality. The TPRA is a measure also of the accuracy of teachers' data as well as their instructional accuracy. Teachers receive hundreds of these observations in their training. The observations also act to assist in the isolation of more effective tactics for individual students. It is an inexpensive procedure and involves little or no time outside of the in-situ setting. This procedure alone can dramatically improve instructional quality. The references include current and in-press sources for using the procedure.

Learn Units and Learn-Unit Productivity

The learn unit is a measure of both the accuracy of teacher presentations and the productivity of therapists or teachers (Greer & McDonough, 1999). The learn unit is a complex but robust predictor of student or client outcomes. In CABAS® schools, we graph all learn units received by students by curricular areas and individual programs. We also measure the learn units taught by practitioners. In the training of practitioners, increasing the numbers of learn units taught is part of the *contingency shaped modules* and trainees and Master Teachers alike have individual targets. The learn units taught to students by curricular area are critical in assessing whether the client is receiving necessary and sufficient instruction. We use learn units along with *inventories of behaviors* to keep us on target with our *behavioralized* versions of national standards. The inventories recast state and national educational standards in terms of antecedent and consequent conditions as well as behaviors and setting events (Department of Educational Excellence, 1998; New York State Department of Education, 1998). In addition, we graph learn units to criterion at the levels of individual clients, practitioners, classrooms, and across all of the classrooms in the school. These data also allow us to determine costs per learn unit and costs per correct response, providing what may be the first cost-benefit measure of education or therapy. For example, in the Cork CABAS® school in Ireland learn units were averaging 21 pence per learn unit and 23 pence per correct response (before conversion of Irish Punts to Euros). Students in CABAS® schools, that provide one to one instruction to pre-listeners and early speakers, typically provide from 700 to 1,000 learn units per child per school day. In some regular and special education classes that are not based on behavior analysis, teachers provide as few as 56 learn units across 30 children in a day (Greer, 1994b). The TPRA observation provides continuous checks on the reliability of learn units presented by teachers.

Decision Tree Protocol

One of the key aspects of quality instruction is the accuracy of the practitioner's use of visual displays of data to insure that the student/client is making progress towards long and short-term objectives. This is a key means of monitoring the degree to which the practitioner is acting as a *strategic scientist*. Over the last few years we have identified approximately 200 tested tactics in the applied literature (Greer, in press). Fitting the appropriate tactic to the momentary need of the client is critical and this repertoire explains why instruction is still a strategic science rather than a technology alone. Our research shows to date that when these decisions are done consistently with our decision tree students learn significantly more (Keohane, 1997; Nuzzola-Gomez, 2002). Learn units to criteria decrease drastically and outcomes increase as costs decrease. While it is a complex procedure, we can teach practitioners to increase their accurate use of tactics through our PSI adaptation. Practitioners learn at the first level when a decision is needed and to seek assistance from more advanced practitioners. Simultaneously, we teach practitioners to use these *verbally mediated* decision steps in graduated levels of independence. For example, we increased our decision accuracy and hence our student objectives from 60 % to 90% by employing this operation throughout our schools. The savings in time and money are obvious. The references include sources to learn about the decision tree process.

Program Summary and Supervision Data

Providing continuous visual displays of units of schools and the total school allow us to monitor all of the components of our program from the individual student to our parent education programs. Data on supervisors' learn units to teachers, as well as the rate of supervisors' accomplishment of tasks that are empirically tied to student outcomes, allows us to revise or redesign aspects of our program in an efficient and collegial manner. A problem in one part of the system is traceable to other parts and solutions from the science may be used to fix the problem. Often problems that are found in the summary data lead to new research and, in turn, new solutions. In still other studies we found that computerized data management led to significant improvements in client outcomes (Babbit, 1986). In a later section of this paper we provide examples of our some of our data displays for the development and maintenance of quality.

Curriculum Revisions

Research in Skinner's theory of communicative behavior has led to recasting all of our curricula not just the basic communication curricula (Skinner, 1957). In a recent paper, we summarized over 28 experiments testing application of verbal behavior to curricula for children ranging form teaching them basic mands and tacts, including first instances of vocal verbal behavior, to teaching problem solving and effective writing repertoires (Greer & Ross, in press). These experiments and the applications to curricula to several hundred students have drastically altered the prognoses for these students and, in turn, our view of curricula. For example, we recast national, state, and international standards into function repertoires of verbal behavior ranging form academic literacy to problem solving repertoires. While our research was directed primarily towards finding better curricula, the work has made several conceptual research contributions to Skinner's theory (Catania, 1998).

CABAS® AND QUALITY

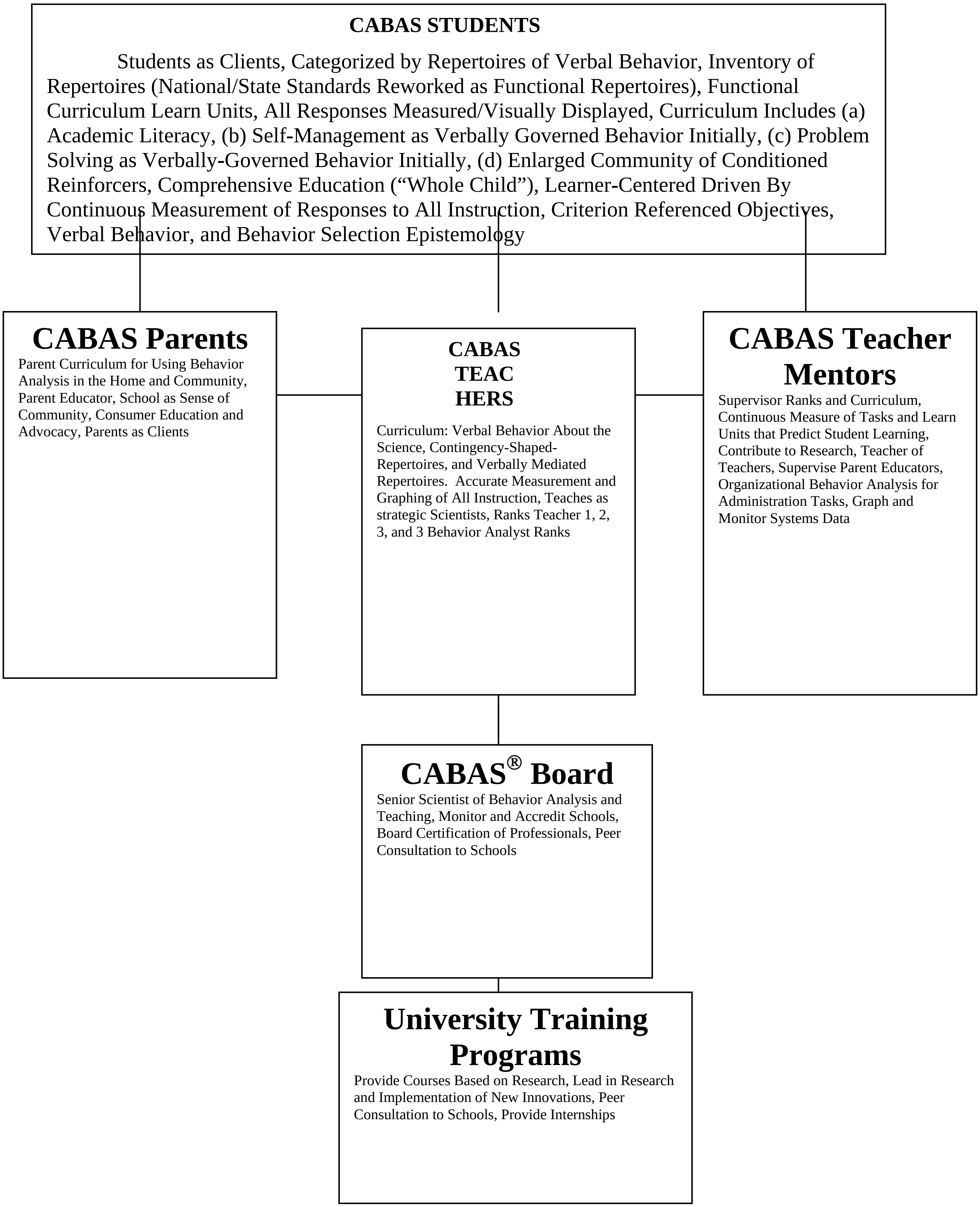
Several years ago we obtained an intellectual trademark for CABAS. This was done in order to preserve the quality and integrity of our programs. All of our research findings are, or will be made available to behavior analysts everywhere; however, in order for a school or a practitioner to describe themselves as CABAS® they must meet certain standards. Schools must show via reliable data that they are implementing all of the components of the program in a reliable and expert manner (Greer, 1997a). Practitioners who are endorsed by CABAS® must be board certified by the CABAS® professional advisory board. While CABAS® is a limited liability corporation, it is not designed to be a profit-making corporation. Our teachers are employed by not-for-profit private or public schools (both union and nonunion), as are our supervisors. Professors at Columbia University, St. Johns University, and City University and one full time person serve as consultants. All of the board members are Senior CABAS® Behavior Analysts, and they consult and provide peer reviews for the CABAS® schools including a small program for Early Childhood Intervention in homes. Thus, the Board functions as an accrediting agency that is designed to insure that when a parent or school district is receiving CABAS® instruction there are standards in place to monitor the quality and productivity of comprehensive applications of behavior analysis. In addition the Board reviews candidates from CABAS® schools for Board Certification at the various levels of expertise.

CABAS® has been tied to the graduate program in applied behavior analysis and the education of students with behavioral disorders (MA, Ed.D, and Ph.D. programs) at Columbia University Teachers College and Graduate School of Arts and Sciences, but professors at CUNY and St Johns University are now involved. Students in university programs spend one or more years in CABAS® schools in paid or unpaid internships and these positions insure training experiences, funding for graduate students, and a source of qualified teaching assistants for the schools. In at least two cases (in the USA and in Ireland), the development of CABAS® schools have led to the development of new university graduate programs in applied behavior analysis. CABAS® has also acted to bring quality behavior analytic schools to Ireland and England. Rather than seeking grants, our funding has been directly tied to immediate as well as long-term benefits for children and schools. Like the program at the University of Nevada at Reno, our schools and our graduate program generate income based on service to the community. Salaries of practitioners are consistent with teacher and supervisor remuneration and the consultant fees come from the schools themselves and are standard levels for school consultation fees. One of our ongoing goals is to decrease costs, increase outcomes and spread the expertise such that the behavior analysts are indigenous practitioners in each culture in which the practices occur.

GENERAL DESCRIPTIONS OF THE CABAS® BEHAVIOR ANALYSIS SYSTEM

The research base for CABAS® has been summarized in several papers, along with citations to the research on which the model is based. We point the reader to these sources in the references. In brief, the CABAS® system seeks to apply behavior analysis to *all of the components of schooling* and the people involved in the manner that the research and the data from our daily practice dictate. These components include pedagogy, curricula, supervision, administration, and the roles of students, parents, supervisors, and the university training program. Figure 1 outlines the components of CABAS® briefly.

Figure 1


CABAS STUDENTS
Students as Clients, Categorized by Repertoires of Verbal Behavior, Inventory of Repertoires (National/State Standards Reworked as Functional Repertoires), Functional Curriculum Learn Units, All Responses Measured/Visually Displayed, Curriculum Includes (a) Academic Literacy, (b) Self-Management as Verbally Governed Behavior Initially, (c) Problem Solving as Verbally-Governed Behavior Initially, (d) Enlarged Community of Conditioned Reinforcers, Comprehensive Education ("Whole Child"), Learner-Centered Driven By Continuous Measurement of Responses to All Instruction, Criterion Referenced Objectives, Verbal Behavior, and Behavior Selection Epistemology
CABAS Parents
Parent Curriculum for Using Behavior Analysis in the Home and Community, Parent Educator, School as Sense of Community, Consumer Education and Advocacy, Parents as Clients
CABAS TEAC HERS
Curriculum: Verbal Behavior About the Science, Contingency-Shaped-Repertoires, and Verbally Mediated Repertoires. Accurate Measurement and Graphing of All Instruction, Teaches as strategic Scientists, Ranks Teacher 1, 2, 3, and 3 Behavior Analyst Ranks
CABAS Teacher Mentors
Supervisor Ranks and Curriculum, Continuous Measure of Tasks and Learn Units that Predict Student Learning, Contribute to Research, Teacher of Teachers, Supervise Parent Educators, Organizational Behavior Analysis for Administration Tasks, Graph and Monitor Systems Data
CABAS® Board
Senior Scientist of Behavior Analysis and Teaching, Monitor and Accredit Schools, Board Certification of Professionals, Peer Consultation to Schools
University Training Programs
Provide Courses Based on Research, Lead in Research and Implementation of New Innovations, Peer Consultation to Schools, Provide Internships

EXAMPLES OF DATA FROM TWO CABAS® SCHOOLS

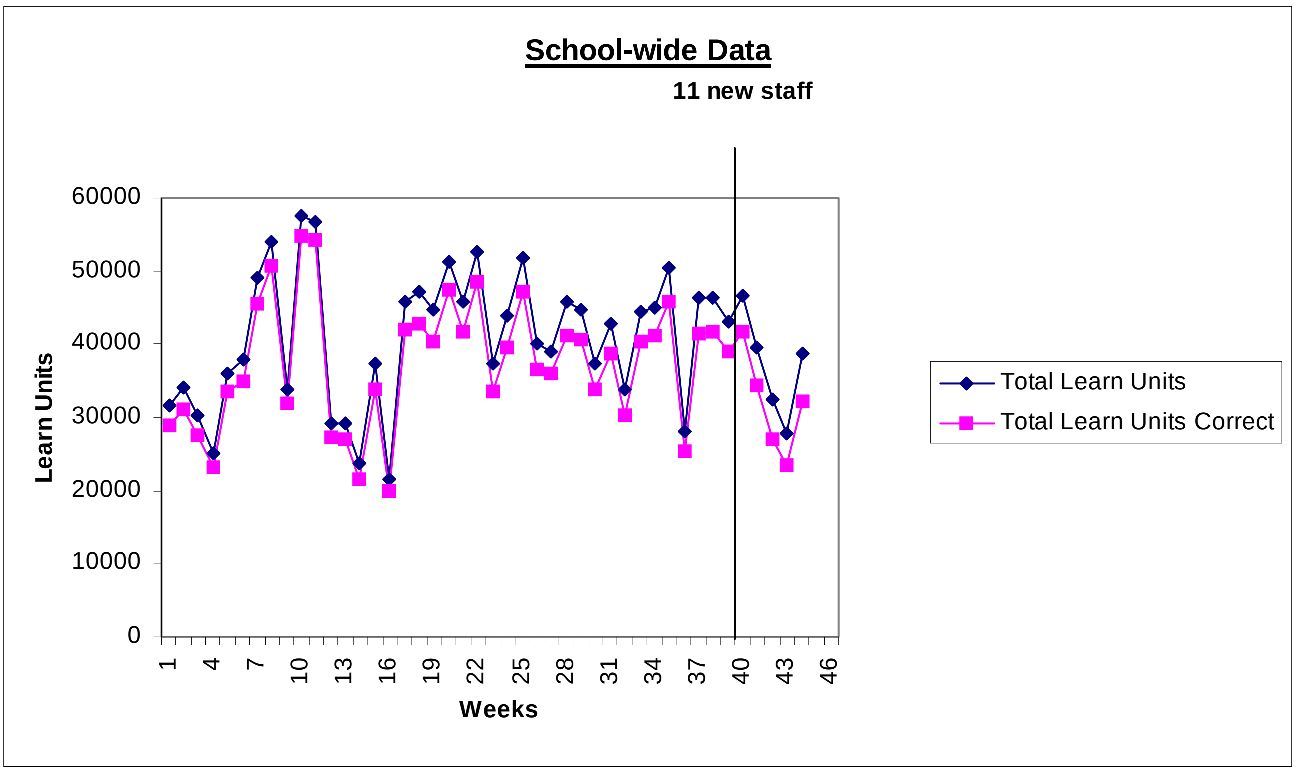
Comprehensive measurement is a key characteristic of all CABAS® Schools. The analysis of data at the individual and system level is ongoing and provides the basis for all strategic and tactical decisions made on students, teachers, supervisors, parents, and other components of the system. The following are brief descriptions and examples of a small portion the data gathered within two CABAS® Schools at the system and individual levels. Due to the limitations of space we provide only a few examples that are tied to professional expertise. The first school data are from the Cork CABAS® School in Ireland that is for children with autism diagnoses ages 3 to 5 years at entry and who range from pre-listeners to early self-editors.

Cork CABAS® School (Students with Pre-Listener to Reader Writer Repertoires)

School-wide and System-Wide Data. These data include a summary of the number of learn units completed across all students in the school weekly along with the number of learn units correct. The percent correct and cumulative numbers of criteria achieved are also graphed detailing the overall performance of the school body. The numbers of learn units to criteria achieved across all teachers and students are graphed and these displays allow an analysis of the teachers' expertise in reaching short term and long-term goals with their students—a measure of quality (See Figure 2). A unique ability of the CABAS® schools is their capacities to provide costs per learn unit and short-term objectives. In addition the performance of supervisors, classrooms, parent educators, and parents are displayed as components of the system.

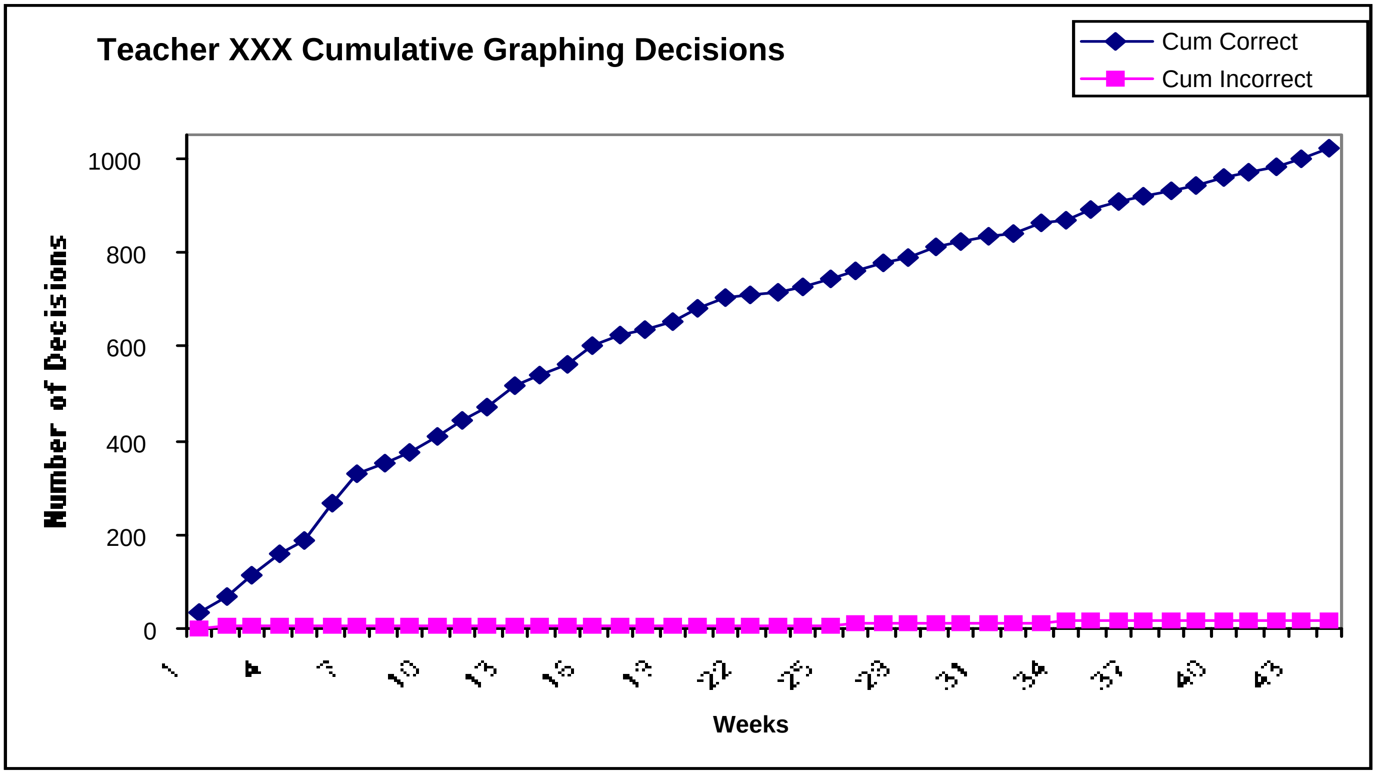
Individual. Data are visually displayed on each student that include both the numbers of learn units received and the numbers of correct responses to learn units, along with cumulative objectives achieved daily, weekly, monthly, and yearly. The numbers of learn units-to-criterion are also recorded and displayed to alert the teachers and supervisors to any problems in acquisition of goals by students or teachers.

Figure 2. All learn units presented by teachers and correct responses of students to learn units for all students in the Cork CABAS® School during 2000-2001.



The measurement of performance extends beyond the students to the *teachers* within the school. The CABAS® system draws on the entire behavioral research literature for analyzing the sources of teaching and learning problems and supplying individualized interventions for students, parents, and professionals. Intensive and individualized interactions involve two persons, both child and educator. Many behavioral approaches analyze and monitor the child's progress, but forget to measure the effectiveness of the educator in presenting the teaching material or in shaping the target response. This latter measure is the key to providing *quality* instruction. In addition to a detailed analysis of the curriculum as we described earlier. Training teachers in CABAS® involves 30 comprehensive learning and practice modules (over 300 components or learning objectives for teachers) covering the three repertoires of teaching and research into the application of behavior analysis to students, teachers, supervisors, parents, and consultants. All CABAS® staff members continuously work on module components ranging from those who are novices to those who are expert. Supervisors work on more advanced modules

Figure 3. Strategic and tactical decisions made by one of the teachers at the Cork CABAS® School during 2000-2001.

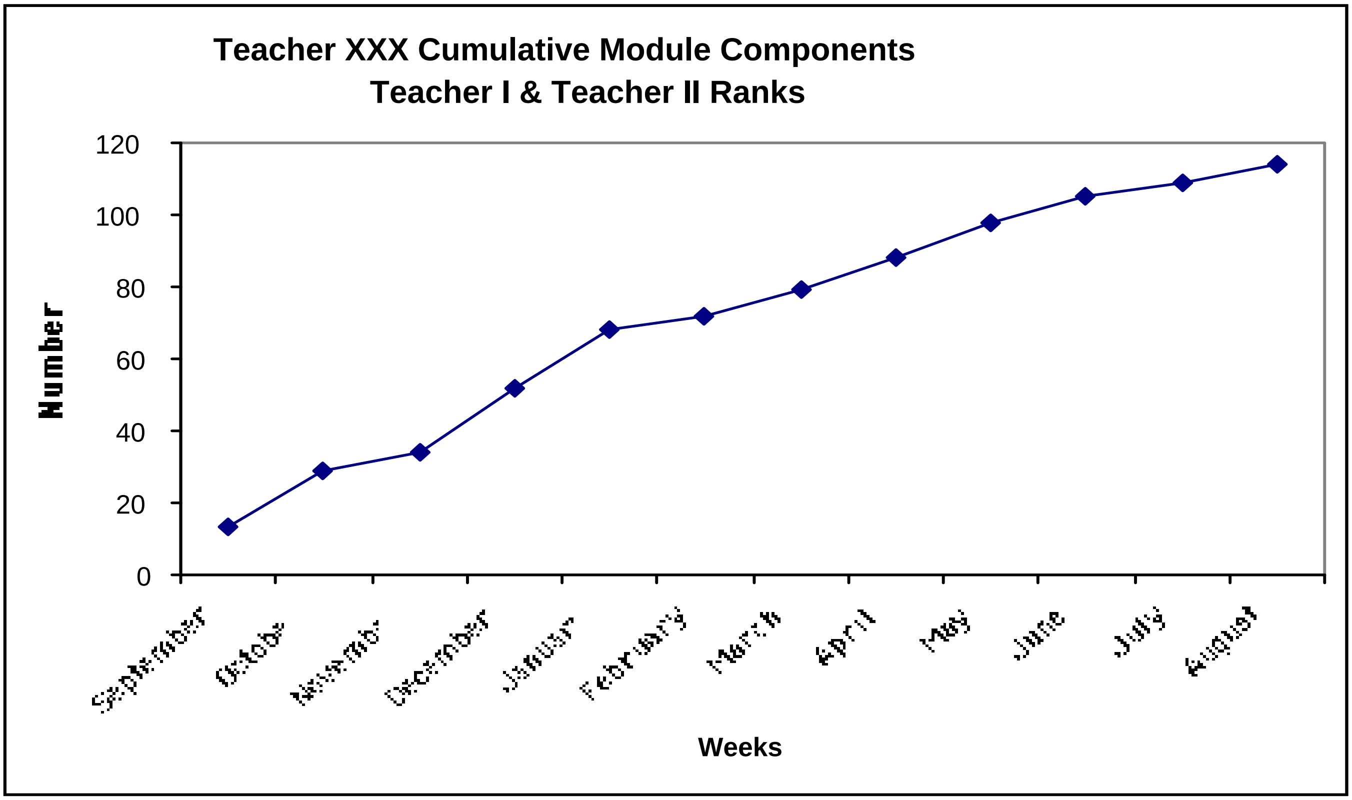


level of effective and appropriate teaching of teachers, we prove continuous assessment and monitoring of all professionals in the system at all levels. This emphasis on *both* sides of the learning equation, and on all individuals at all levels of participation allows us to maintain a *system of instruction* that is constantly evolving and self-correcting. Each teacher is monitored closely by a supervisor examining the teacher's numbers of learn units completed and numbers of correct student responses and learn units to criteria for the students he or she works with daily and weekly. The graphs on teacher performance also display the cumulative numbers of criteria reached by students while taught by the particular teacher. Another core element of teacher training is the measurement of the numbers of module components completed by each teacher monthly in the teacher devoted to mentorship, replication and seminal research, acquisition of knowledge of new conceptual issues and research findings in the field, and design of curricula. Our parents work on modules devoted to applying behavior analysis to the range of parenting demands.

The mastery of modules by teachers and other professionals reflect the number and accuracy of instructional decisions based both on when a decision is needed and the choice of *tactics*. Modules also reflect the achievement of errorless Teacher Performance Rate of Accuracy completed by each teacher and the learn units taught. Graphs display each of these measures of teachers (See Figures 3 and 4). Several of our students are enrolled simultaneously in graduate programs in psychology in the Irish Universities.

The displays of data in each child's curriculum book and along the school corridors provide a high level of accountability to all people involved in the system and simultaneously reflect still another application of behavior analysis research findings on the effects of visual displays on performance. Figures 2, 3, and 4 are graphs of data gathered at the Cork CABAS® School in Ireland. The Cork CABAS® School was the first school for children with autism in Ireland and was funded by the Department of Education of Ireland initially as a pilot project for a one to one program for 12 children. During the year displayed, the number of teachers was increased to 24 with a corresponding increase in students at the beginning of the following year (not shown). The fall in the data at week 40 represents the influx of new staff training within the school before the additional students entered during the next school year and reflect the skills of the new teachers. Currently, there are thirty students in the Cork school including 6 students who are in the mainstream for most of their schooling. A second school was begun in Dublin in November of 2001.

Figure 4. Cumulative module components from one complete Teacher Rank and part of the second rank completed by a teacher at the Cork CABAS® School during 2000-2001.



CABAS Middle School in the USA (Students with Reader Writer Repertoires)

The following data are from a public middle school for students with behavior disorders who are from low-income families. The school serves 40 students in sixth, seventh, and eighth grades with early reader to self-editing repertoires. The teachers all received their Master's degrees in teaching as applied behavior analysis at Columbia University Teachers College and have completed between one and a half to three CABAS® Board certified ranks (125 to 247 module components). Three of the teachers are currently doctoral students in the University program and two are working toward CABAS® board certified assistant behavior analysts ranks. Additionally, seven of the teacher assistants at the school are students in the Master's program and have completed a total of 580 module components (23 complete modules) over the last four months. There is also a full time CABAS® Board certified Senior Behavior Analyst (a Senior Behavior Analyst rank is comprised of 60 modules beyond the teacher modules) who serves as a mentor for the teachers and teacher assistants and provides data analysis and data summary for the school as a whole (see figure 5).

Figure 5. The Cumulative Number of Modules and Module Components Completed Across 5 Teachers (Teacher I, Teacher II, and Master Teacher Ranks) and 10 Teacher Assistants (Teacher I, and Teacher II Ranks) at a CABAS® Middle School in the United States.

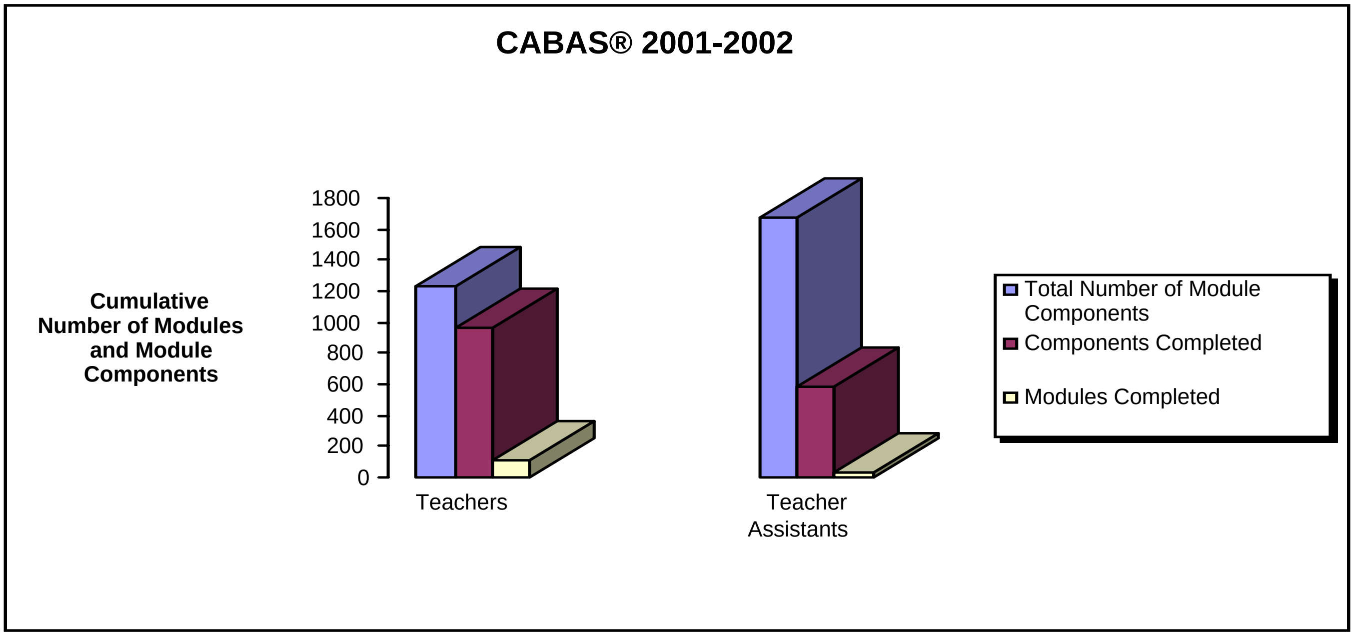
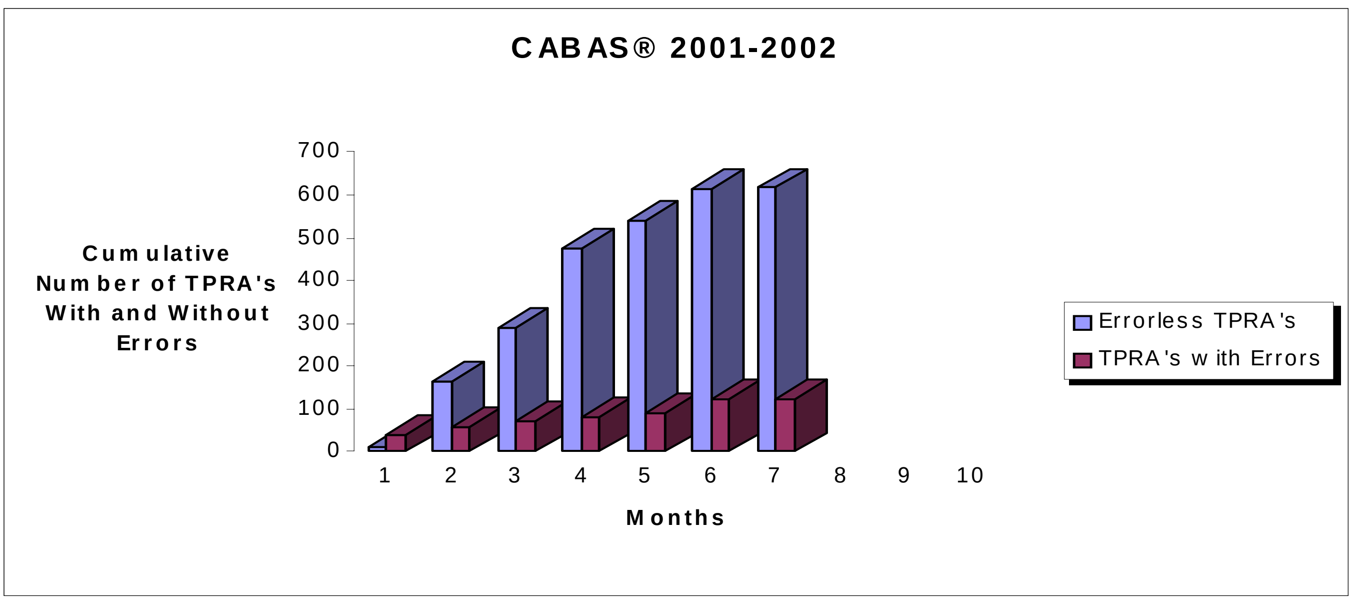


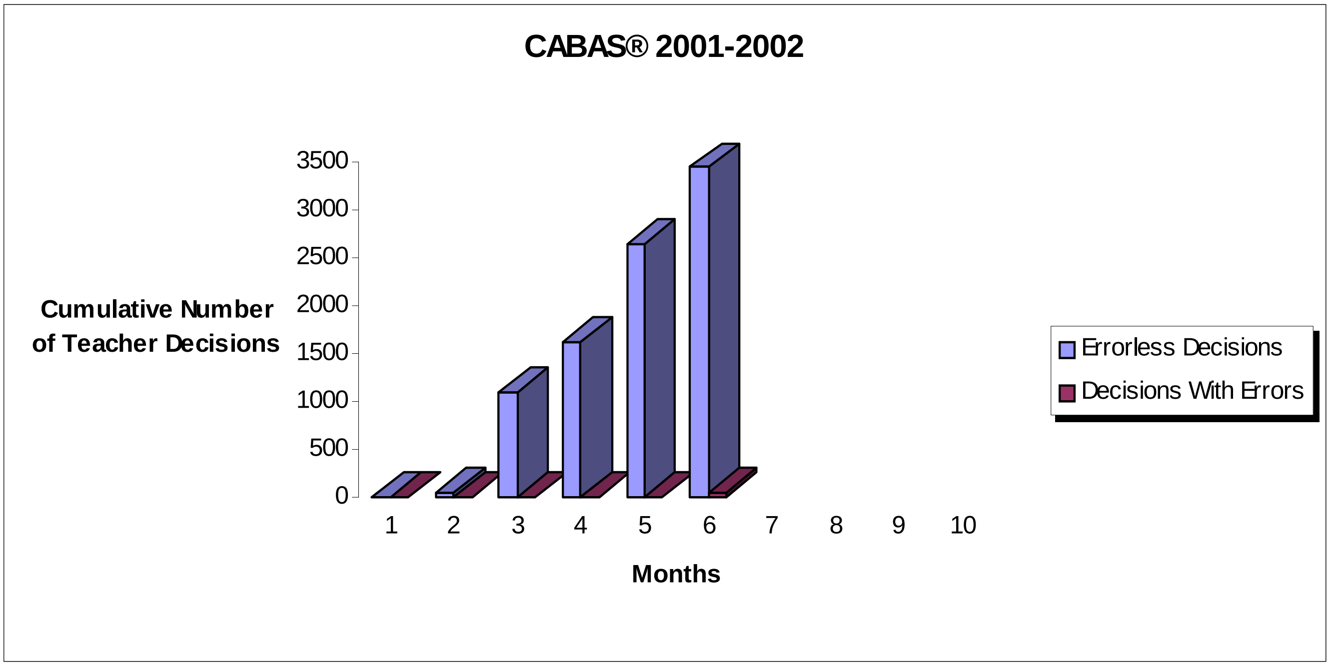
Figure 6. The Cumulative Number of TPRAs Per Month With and Without Errors at a CABAS® Middle School in the United States.



The Teacher Performance Rate and Accuracy observations provide the supervisor with an important source of measurement and help facilitate the identification of pedagogical curricular problems at both the conceptual and implementation levels. They are also critical components of the curriculum for teachers. During TPRA observation sessions, the supervisor's behavior is affected by the contingencies along with that of the student and the teacher. As the supervisor measures the teacher's rate and accuracy of the delivery of each learn unit to the student, the teacher's presentation and consequation become the antecedent and the behavior which the supervisor must appropriately consequate. The supervisor provides curricular modifications and strategic/tactical assistance during TPRAs based on the students' and teachers' 'moment –to- moment' responses. Reinforcement and corrections are given in both written and vocal form to teachers and thus provide learn units to teachers (see figure 6). The numbers of TPRAs provided to teachers are strong predictors of learn units taught and correct student responses across all students taught by the teachers (Greer et al., 1989).

Teachers make all instructional decisions based on a graphic display of data. Data are typically graphed immediately after they are summarized so that the teacher can analyze the trend according to the CABAS® decision tree protocol (See Figure 7). The teachers and teacher assistants (as appropriate) make decisions at proscribed junctures and maintain a count of both errorless decisions and those made in error (based on a strategic analysis of the problem in the learn unit context and the associated tactic from the 200 research-based tactics in the literature). The decision accuracy measures are critical components of developing and maintaining quality and they are essential components of the teachers' curriculum as well. Tactics that are not related to the learn unit context or those that are not from the research literature are tallied as errors.

Figure 7. The Cumulative Number of Teacher Decisions Per Month With and Without Errors at a CABAS® Middle School in the United States.



MONITORING AND ACCREDITATION OF SCHOOLS AND STAFF ACROSS SCHOOLS

The CABAS® professional advisory board monitors all of the schools. All of the board members hold a Ph.D. in the field of behavior analysis and education and all hold ranks of Senior Behavior Analysts or Senior Research Scientists. Membership is voluntary and unpaid. We seek to develop a few exemplary schools that provide and demonstrate quality behavior analytic education that serve to improve the model through continuing research and demonstration. We expect that only a few schools will meet the rigorous standards of the model. However, we seek to see that the procedures and the example of a systems wide approach adopted and adapted by other school programs/service providers and other graduate training programs. For example, providers of behavior analytic services can draw on the research and demonstration of CABAS efforts to improve the quality and productivity of their own individual efforts, and indeed improve on them through their on research. In this way we hope to have a wider impact not on simply the *reform* of educational practices but rather, the *redesign* of practices. We adhere to Skinner's dedication to the critical need for application of science for man, "we have yet to see what man can make of man." (Skinner, 1971, p.215) While saving the world is beyond our scope as behavior analyst educators, we can, and do, save a few children. We hope that our work can be useful to other providers of behavior analytic services in education and therapy.

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ETIOLOGY AND TREATMENT OF CHILD AND ADOLESCENT ANTISOCIAL BEHAVIOR

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Evidence is presented showing that aggression is functional. The reinforcers provided vary as a function of age and setting. During the toddler years, negative reinforcing contingencies supplied by the caretaker and family members control the occurrence of overt forms of antisocial behavior. Beginning during school years, positive reinforcers supplied by members of the deviant peer group shape and control the occurrence of covert forms. Boys who move through both of these developmental stages are at risk for early police arrest, and in turn for chronic juvenile and adult offending. Studies in the early 1970s showed that training parents to alter these contingencies effectively reduced rates of antisocial behavior. These behavioral approaches have been tested in numerous studies that employ randomized trials, objective measures and follow-up designs. The intervention components have also been extended for use by foster parents trained and supervised in the use of these procedures with chronic offending adolescents. Prior to the adolescents return to their homes, the biological parents are also trained and supervised. Follow-up data show significant reductions in police arrest and rates of institutionalization. Taken together, these findings clearly support the efficacy of behavioral strategies in constructing etiologic models and a set of strategies for effective intervention with antisocial behaviors.

In many respects aggressive behavior is ideally suited to study by behavioral procedures. Antisocial behavior is readily observable in most settings. Observers can be trained to be highly reliable in coding such behavior (Jones, Reid, & Patterson, 1975). It is also a facet of behavior that is highly stable over time. For example, Olweus (1979) showed measures of antisocial behavior to be at least as stable over time as are measures of intelligence. There is modest support for the finding that measures obtained during preschool years are significant predictors for measures obtained as young adults (Kagan & Moss, 1962; Stattin & Magnusson, 1991). Several studies have shown that, given preschool identification as antisocial, then the odds are about 50% to 60% of being so classified as adolescents (Kazdin, Mazurick, & Bass, 1993; Tremblay, Boulerice, Pihl, Vitaro, & Zoccolillo, 1996). One interesting finding from studies such as these is that during late childhood, there are only very small numbers of new cases added. It seems then that most chronic antisocial individuals begin the trajectory during preschool years (Fergusson, Horwood, & Lynskey, 1995; Nagin & Tremblay, 1999; Patterson, Shaw, Snyder, & Yoerger, 2001). Epidemiologists estimate that about 8% of boys and fewer than 3% of girls might fit the definition of demonstrating early emerging and persisting extreme antisocial behavior (Offord, Boyle, & Racine, 1991).

There is also an interconnectedness among the different forms of antisocial behavior. Children who engage in high rates of noncompliance are at significant risk for also engaging in higher rates of hitting, fighting, and stealing (Patterson, Reid, & Dishion, 1992). Adolescents who engage in high rates of trivial delinquent acts (e.g., petty theft) also tend to engage in high rates of violent delinquent acts (Capaldi & Patterson, 1996). This suggests that although each antisocial behavior may be maintained by its own set of contingencies, there may be some general sense in which they are all part of the same system.

Childhood forms of antisocial behavior have been shown to be significant predictors for lifetime failures in achievement as shown in the pioneering longitudinal study by Huesmann, Eron, and Yarmel (1987). In keeping with this assumption, Olweus

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(1983) studied a large sample of Norwegian boys and found a significant path from antisocial behavior to poor grades. In an at-risk Oregon sample, a structural equation model showed a path coefficient of -.57 from a latent construct for antisocial behavior to a latent construct for achievement (Patterson et al., 1992). We view antisocial behavior as a major mechanism causing not only academic failure but also failure in such key domains as social relationships (Shortt, Capaldi, Dishion, Bank, & Owen, 2002), health (Patterson & Yoerger, 1995), and work history (Wiesner, Vondracek, Capaldi, & Porfeli, 2002). For example, antisocial individuals persist in their use of aversive events to alter the behavior of others. This leads to rapid rejection by normal peers as shown in two experimental manipulation studies by Dodge (1983) and Coie and Kupersmidt (1983).

Several features of antisocial behavior brought it to center focus for the National Institute of Mental Health (NIMH) funding beginning in the late 1960s. From half to two thirds of all referrals for child clinical agencies consisted of externalizing type problems, such as antisocial and hyperactive behavior. At that time, there were no interventions shown to be effective by well-designed (randomized trial, objective measures) studies. The NIMH began funding research destined to fill the gaps in building more effective models for both theory and intervention.

EMPIRICALLY BASED MODELS FOR CHILDREN'S ANTISOCIAL BEHAVIOR

We assumed the extent to which aggressive responses are selected by a child reflect, in some sense, the extent to which they were reinforced. Within this framework, children who engage in aggressive behaviors do so because they are reinforced for it. However, in the mid-1960s, we had no idea about the nature of the reinforcer, who delivers it, or what determines when it will be provided. At that time, we and other developmental psychologists carried out dozens of laboratory studies where children were reinforced with M&M candies or praise contingent on their punching a rubber clown. The findings from these studies were totally irrelevant to understanding questions of how aggression functioned in the real world.

We decided to send observers into natural settings to provide a basis for carrying out a functional analysis of children's antisocial behavior. A simple code system described each episode in which a nursery school child was aggressive to another (Patterson, Littman, & Bricker, 1967). The other child's reaction to the attack was also coded, together with the attacker's subsequent reaction. The data showed that roughly 80% of the 2,583 aggressive events were followed by such outcomes as "victim cries" or "victim gives up toy." From the attacker's view, these would be positive outcomes. The outcomes seldom involved such negative outcomes as teacher intervenes or victim retaliates.

The findings suggested that for young children in a nursery school setting, antisocial acts were indeed functional. Given lax control from adults, the reinforcers for child aggression seemed to be supplied by the victim. If the consequences supplied by victims served as reinforcers, then it should be the case that during the same episode the aggressor is more likely to continue attacking the same victim. It could also be that the aggressor would continue the same form of attack. Given punishing consequence (victim hits back), then the aggressor would be more likely to select a different victim and/or a different form of attack. A 2-(positive or negative consequences) by-2 (continue or stop attack) table was constructed for each of the nine most aggressive boys. Seven of the nine chi-square values were significant. These findings showed that consequences judged a priori to be positive or negative were reliably related to the future attacks.

Snyder and Patterson (1986) extended the strategy to demonstrate that given a sequence mother behavior X and child reaction pattern Y followed by termination of the bout increased the probability that in the future when mother behavior was X, the child was significantly more likely to react by Y. Notice that even in these complex social interaction situations, contingencies supplied by one person altered the future behavior of another. Notice, too, that these simple correlational strategies were useful in identifying those consequences in interactional sequences that might function as reinforcing contingencies when subjected to experimental tests. Relevant experimental manipulation studies will be reviewed in a later section.

Historically, developmental theorists assumed that the genesis for children's aggression would be found in family process (Maccoby & Martin, 1983). However, a decade's effort to use self-report measures failed to establish a reliable connection between parenting practices and child aggression (Maccoby & Martin; Schuck, 1974). We hypothesized that the failure reflected a failure in measurement. Presumably, multimethod and multiagent measures of family process, particularly those based on observation data, would provide more reliable and valid predictors to child outcomes. We spent 3 years developing a code system that described sequential family interactions among family members (Jones et al., 1975; Reid, 1978). The code was later updated so that data could be collected in real time and stored in a small hand held computer (Dishion, Gardner, Patterson, Reid, & Thibodeaux, 1983). Up to 10 hours of baseline observations were collected in the homes of both normal and clinical families.

The home observation data provided a turning point in our thinking about children's aggression (Patterson & Cobb, 197l, 1973). Hundreds of hours spent observing in the homes of normal and clinical families identified an unexpected reinforcer for children's aggressive behavior. The data showed that children from families referred for treatment of aggression must learn to cope with very high rates of irritable behaviors. All family members, including the identified problem child, learn to employ aversive behaviors to terminate conflict bouts with other family members (Patterson, 1982). The data showed that in clinical families, conflict bouts occurred about once every 16 minutes. In these problem families, 10% to 15 % of their interactions with each other tended to be aversive (Patterson et al., 1992). The most likely antecedent for a problem child's aversive response was the aversive behavior of other family members (Patterson, 1976). There were, in fact, specific networks of aversive stimuli found in many families that reliably produced outcomes such as child hitting and teasing. Those two responses, in turn, formed a functional response class that reliably produced hitting, teasing, and yelling reactions from family members (Patterson, 1982). Hitting and teasing formed a functionally defined response class.

In normal families, conflict bouts occurred at much lower rates and might be successfully terminated when the child displayed either prosocial (e.g., talking, negotiating, or using humor) or coercive (e.g., yelling, arguing, or hitting) reactions (Snyder & Patterson, 1995). However, in clinical families, the process was markedly different. In these families, it was primarily coercive reactions that were reinforced by termination of conflict bouts.

The observation studies showed that training for aggression begins in the home, and it occurs primarily during conflict bouts. The contingencies provided fit the definition for negative reinforcement. For example, a sequence may begin with the aversive behavior of another family member. The child reacts aversively and may escalate to a higher amplitude aversive behavior (Snyder, Edwards, McGraw, Kilgore, & Holton, 1994). Given this sequence in clinical families, the child's coercive reaction is significantly more likely to be followed by termination of the conflict bout.

We designed a series of laboratory experiments to test for the efficiency of parent negative reinforcement in shaping child outcomes (reviewed in Patterson, 1982). For example, a study by Devine (197l) used mother nonavailability as an aversive event. In the trial, mother availability could be made contingent on either child prosocial or deviant behavior. These pairings could be used to significantly increase either child prosocial or deviant targeted behaviors in as few as four trials. Woo (1978) used observation data collected in the home to identify, for each of three dyads, a functional relation between an aversive mother behavior and a child coercive reaction. Negative reinforcing contingencies produced massive increases in pre-existing coercive patterns for all three dyads. Neither of these studies employed reversal or multiple baseline designs. Therefore, some uncertainty remains about the status of these contingencies as reinforcers. Even more importantly, we had no information on the overall contribution of negative reinforcement to individual differences in aggression.

Edward Carr carried out a series of classroom studies with children with disabilities that explored the coercion mechanism (negative reinforcement) in elegant detail. Observation data were used for a precise identification of the aversive stimuli. The experiments manipulated such child outcomes as self-destructive and aggressive behavior (Carr, Newsom, & Binkoff, 1976, 1980). For example, adult requests and commands were associated with an increase in risk for child aggressiveness. Reversal designs showed dramatic changes in aggressiveness as a function of how effective it was in escaping from adult requests. Carr developed the idea that too little or too much adult attention could function as aversive stimuli for some children with disablities (Carr, 1988). In his later studies, he demonstrated that it was possible to train the child to use communication skills as a replacement for deviant behavior. Horner and Day (1991) and Piggot (1995) have continued this research with studies showing that negative reinforcement serves as a key mechanism for a wide spectrum of deviant child behaviors.

The studies reviewed thus far show that parents can manipulate negative reinforcement contingencies, and in so doing, change both prosocial and coercive child behaviors. The classroom studies showed that there are behaviors in children with disabilities that are shaped by negative reinforcers provided by adult staff. However, these studies do not tell us whether the negative reinforcement mechanism accounts for the wide spectrum of behaviors typically ascribed to antisocial problem children.

To answer these questions, we should be able to measure negative reinforcement in problem and non-problem families to show that the mechanism accounts for the bulk of the variance in measures of antisocial childhood behavior. However, it has been known for decades that covariation between measures of reinforcement density and measures of response strength are asymptotic (nonlinear; Herrnstein, 1961). However, in his studies of the matching law, Herrnstein (1974) went on to demonstrate that in a highly controlled laboratory setting, there was a strong correlation between the relative rate of reinforcement and the relative rate of responding.

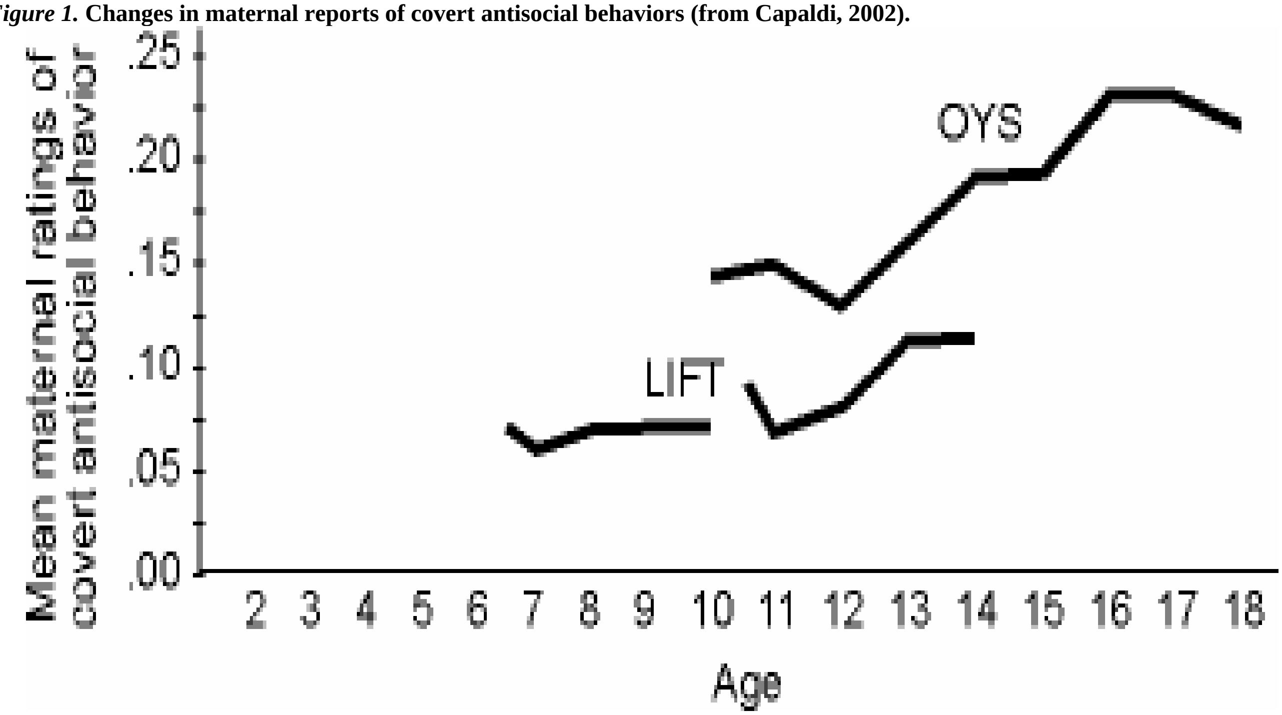
Snyder and Patterson (1995) hypothesized that the strategy could be applied to the study of children's aggression. Presumably, the relative rate of reinforcement for child coercion during conflict bouts would correlate with measures of the child's relative rate of aggression. Observation data assessed the relative rate of negative reinforcement provided during conflict bouts for an at-risk sample of kindergarten-aged boys interacting with their mothers. The key variable was the proportion of successful outcomes (mother terminates conflict) that involved child coercion. The relative rate of negative reinforcement for child coercion was found to correlate .83 with the child coerciveness observed in the home a week later.

In a clinical sample, the reinforcement variables were used to predict a composite (police arrest and out-of-home placement) clinical outcome 2 years later (Snyder, Schrepferman, & St. Peter, 1997). Those boys who received higher relative rates of reinforcement for coercive behaviors when interacting with family members were at greater risk for police arrest and for out-of-home placement 2 years later. It seems then that the coercion mechanism (negative reinforcement) may be a highly generalized mechanism that applies to a wide spectrum of young aggressive boys performing a wide spectrum of antisocial acts.

In the model, it is assumed that parents who use reinforcing contingencies more effectively tend to be those that are generally socially skilled. To test this assumption, we developed four measures of parenting skills. In the hierarchically nested model, contingencies supplied by family members were thought to be the most proximal causal mechanism for coercive and antisocial child outcomes. It is assumed that parenting practices, such as monitoring, discipline, problem solving, and involvement, determine family contingencies. Multimethod, -agent definitions of parenting skills were developed (Patterson et al., 1992) to test the hypotheses that parenting practices should also predict child outcomes. Forgatch (1991) examined structural equation models from three different samples to show that the latent constructs for parenting practices accounted for 30% to 52% of the variance in latent constructs measuring child antisocial behavior. The implication of these findings is that intervention strategies must include provisions for altering parenting practices. Presumably changes in parenting will be associated with changes in the contingencies for coercive behavior found in family interactions.

The third level in the hierarchical model consists of measures of the context in which the family lives, for example, quality of neighborhood, social disadvantage, divorce, and parental depression. It is assumed that the effect of context on child outcomes is mediated by its impact on parenting practices. For example, not all post-divorce families produce antisocial children. The data show that if divorce is accompanied by disrupted parenting, then the family is at risk to produce an antisocial child (Forgatch, Patterson, & Ray, 1996; Forgatch, Patterson, & Skinner, 1988). Models testing the impact of context on child outcome provide consistent support for the mediating role of parenting practices (Conger, Patterson & Gé, 1995; Larzelere & Patterson, 1990).

Figure 1. **Changes in maternal reports of covert antisocial behaviors (from Capaldi, 2002).**



A developmental model must address the fact that children's antisocial behaviors change in form as the child matures (Patterson, 1993; Patterson et al., 2001). Longitudinal studies show that pushing, hitting, kicking, and biting are in evidence as early as 2 years of age (Tremblay et al., 1999). Findings from longitudinal studies show a consistent negative slope for these overt antisocial behaviors from age 2 to early adolescence. The data from longitudinal studies show little evidence of covert antisocial behavior during the elementary grades (Capaldi, 2002). However, as shown in Figure l, there was a dramatic increase in maternal reports of covert antisocial behavior beginning in early adolescence (Patterson et al., 2001; Patterson & Yoerger, 1995). A longitudinal study showed that individuals who display high rates of overt antisocial behavior plus later growth in covert forms are most at risk for early-onset delinquency (Patterson & Yoerger; in press).

Studies of the etiology of covert forms of antisocial behavior are just beginning. The evidence that we have thus far shows that deviant peers may be the primary source for this training. Apparently the process begins when the antisocial child starts school and is quickly rejected by members of the normal peer group (Dishion, Andrews, & Crosby, 1995). The problem child responds to this by selecting a peer group that is similarly deviant (Cairns, Cairns, Neckerman, Gest, & Gariepy, 1988). Observations of these interactions show that problem child and deviant peer interactions are characterized by rich schedules of positive reinforcement for deviant behavior (Dishion, Duncan, Eddy, Fagot, & Fetrow, 1994; Snyder, West, Stockenmer, Gibbons, & Almquist-Parks, 1996). This process continues during adolescence where the antisocial individual carefully selects both friends and romantic partners to match (and reinforce) his own deviancy. Deviant peers both model and provide positive reinforcement for covert forms (e.g. substance use, stealing, cheating, lying, truancy, health-risking sexual behavior) of antisocial behavior. Programmatic observation studies (Dishion et al., 1995) showed that the relative rates of positive reinforcement for deviant talk reliably predict future delinquency. Current studies of deviant peer interactions with at-risk samples of antisocial boys in elementary grades suggest that deviant peers may make a similar contribution to the development of new forms of antisocial behavior as early as the first grade (J. Snyder, personal communication, December 2001). This implies that interventions focus in part on controlling access to deviant peer culture.

The coercion model for antisocial behavior addresses a complex web of relationships that imply status as causal mechanisms (e.g., the relation of inept parenting to the development of antisocial behavior, the relation between parenting practices and involvement with deviant peers, and the relation between deviant peer involvement and the acquisition of covert forms of antisocial behavior). These hypotheses raise the necessity for designing experimental manipulations that can directly test these assumptions.

Recent developments in prevention science have made it possible to subject hypothesized causal mechanisms to experimental tests (Forgatch, 1991). In a series of four of these studies, randomized trials assign some families to experimental conditions that include training in parenting practices and comparison groups who do not receive this training. The findings from all four studies completed thus far are consistent with the hypothesis that changes in parenting cause changes in child outcome (Chamberlain & Reid, 1998; Dishion, Patterson & Kavanagh, 1992; Forgatch & DeGarmo, 1999; Reid, Eddy, Fetrow, & Stoolmiller, 1999). For example, in a prevention trial involving single mothers, DeGarmo and Forgatch (2000) showed a significant reduction in delinquent behavior for the experimental but not for the comparison group. In keeping with the early-onset delinquency model, the effect on child outcome was mediated by improved parenting practices and by reductions in involvements with deviant peers. The fact that investigators in other research settings obtain similar results makes these findings even more convincing. Tremblay and his colleagues at Montreal have included parent training (PT) as one of the key components in their effectiveness trial. Their long-term follow-up data show significant reductions in antisocial behavior (Vitaro, Brendgen, & Tremblay, 1999). The mediating variables were changes in parenting practices.

EMPIRICALLY BASED INTERVENTIONS

Early efforts to treat antisocial children were based on derivatives from psychoanalytic theories (Kessler, 1966). By mid-century a number of large-scale, well-designed studies (randomized trials) had been carried out. It was becoming clear that the therapies practiced in child guidance clinics were ineffective (Levitt, 197l). For example, the classic Cambridge Somerville study (Powers & Witmer, 195l) involved a risk sample of boys thought to be delinquency prone. Those assigned to the experimental group received intensive counseling, monthly caseworker contacts, involvement in boys clubs, and summer camps. The counselor ratings showed significant improvement. However, long-term follow-up by McCord (1976) showed that as adults, the boys in the experimental group actually showed significantly higher rates of crime, alcoholism, and psychiatric illness. The intervention had produced an iatrogenic effect. Similar results were obtained from five other large-scale projects reviewed in Patterson (1979).

A behavioral approach to treating aggressive children emerged in the mid to late 1960s. The research was based on inputs from four different groups: (a) R. Wahler at Tennessee (Wahler, Winkle, Peterson, & Morrison, 1965); (b) S. Bijou through his influence on R. Hawkins (Hawkins, Peterson, Schweid, & Bijou, 1966); and then Christopherson (1990), (c) Bijou also influenced the Eugene, Oregon, group as they attempted to apply operant techniques to parent-child interaction (Johnson & Eyberg, 1975; Patterson & Brodsky, 1966) (d) C. Hanf (1968) had a major impact on the field through her training such outstanding students as R. Forehand and C. Webster Stratton.

The various research groups met often at formal conferences and in informal working groups. Even in the early beginnings, PT had acquired two very salient features. All of us relied heavily upon observation data to provide regular feedback to the therapists. The data were literally pinned to the wall and updated on a daily basis. The second characteristic was a strong conviction that, contrary to the psychoanalytic perspective, the problem was not assumed to be “IN” the child. Alternatively, we believed that the problem was “IN” the social environment. If we were to change child aggressive behavior, we would have to find some means for changing the environment in which the individual lived. Early on, we decided that we should begin by training the parents to change their reactions to the problem child.

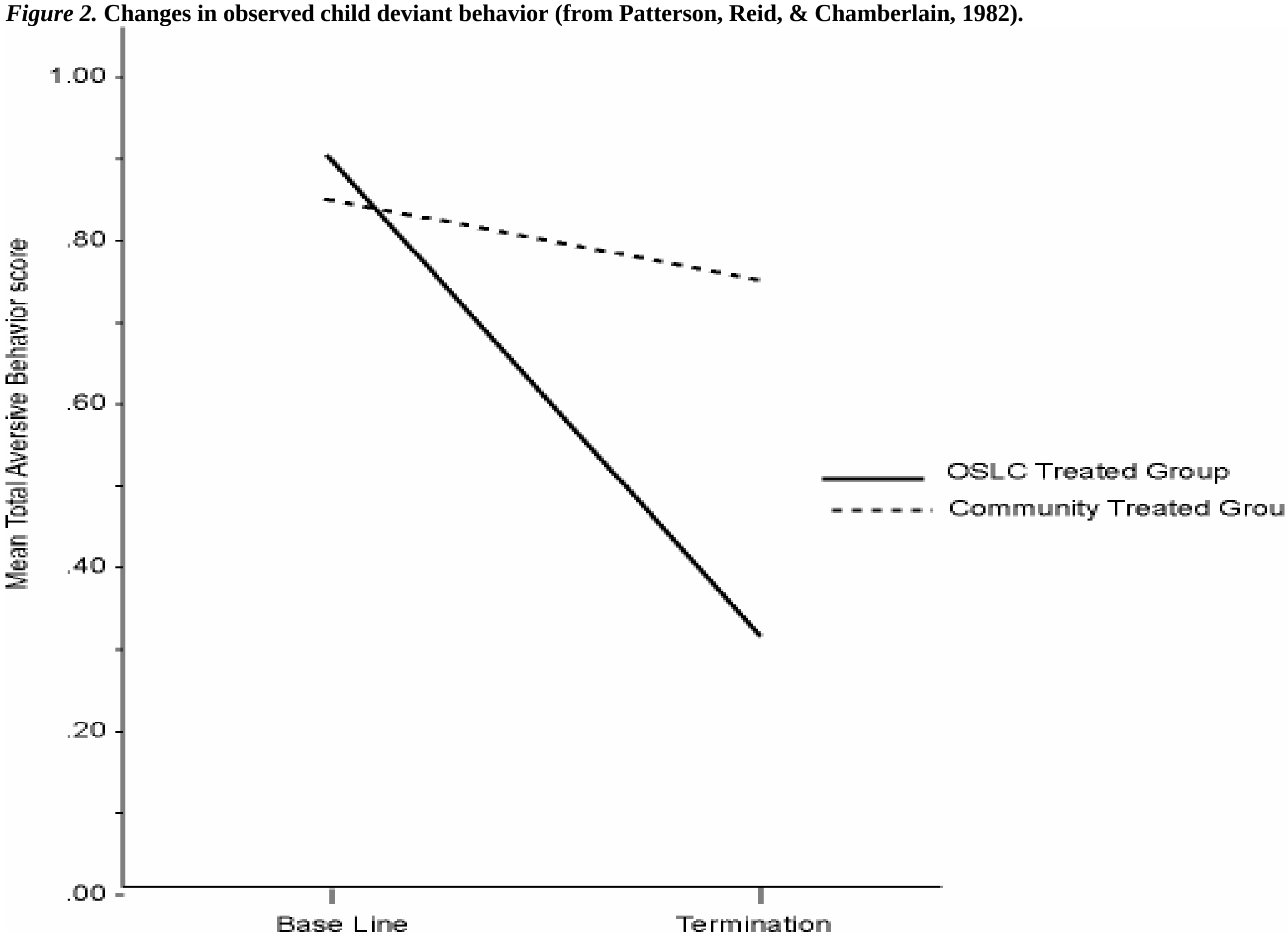
We noticed that there was little or no correlation between maternal reports of improvements during intervention and the reports from observer data. We viewed parent global ratings of improvement as a reinforcement trap (Patterson & Narrett, 1990). For example, we found that if the parent assumed intervention was occurring they reported improvement even though intervention had not begun.

In the early stages we assumed that parents could be trained to simply reinforce responses that competed with aggression (e.g., cooperation, sharing, listening, etc.). The observation data showed that first cases treated in this fashion did not improve. We began to experiment with nonviolent forms of limit setting, such as time out and work chores, as negative consequences. The data showed very rapid changes in observed rates of deviant child behavior. Teaching parents effective limit setting (discipline) has come to be at the core of PT procedures.

We had observed the parents' failure to positively support the child's prosocial behaviors. Typically, the first week or two of intervention was totally invested in tracking and in reinforcing a wide spectrum of socially competent behaviors. For most families of problem children, the procedures almost invariably included programs for accelerating academic achievement. The parent would be encouraged to track homework assignments and arrange a time and place for doing homework. Parenting skills, such as monitoring and family problem solving, were also emphasized. The parents were contacted by telephone once or twice a week to critique the problems that naturally arise in such an enterprise.

Even in the first clinical cases studied the follow-up observations showed that when the intervention was terminated, the mean level of child (and parent) deviancy did not return to baseline (Patterson, 1976). Systematic analyses showed the treatment effect persisted for at least 12 months (Patterson & Fleischman, 1979). ABAB reversal designs were not going to be an effective means for analyzing treatment outcome. We planned instead to eventually rely upon randomized trials with data collection at pre-, post-, and follow-up. The published findings for the first 27 treated cases

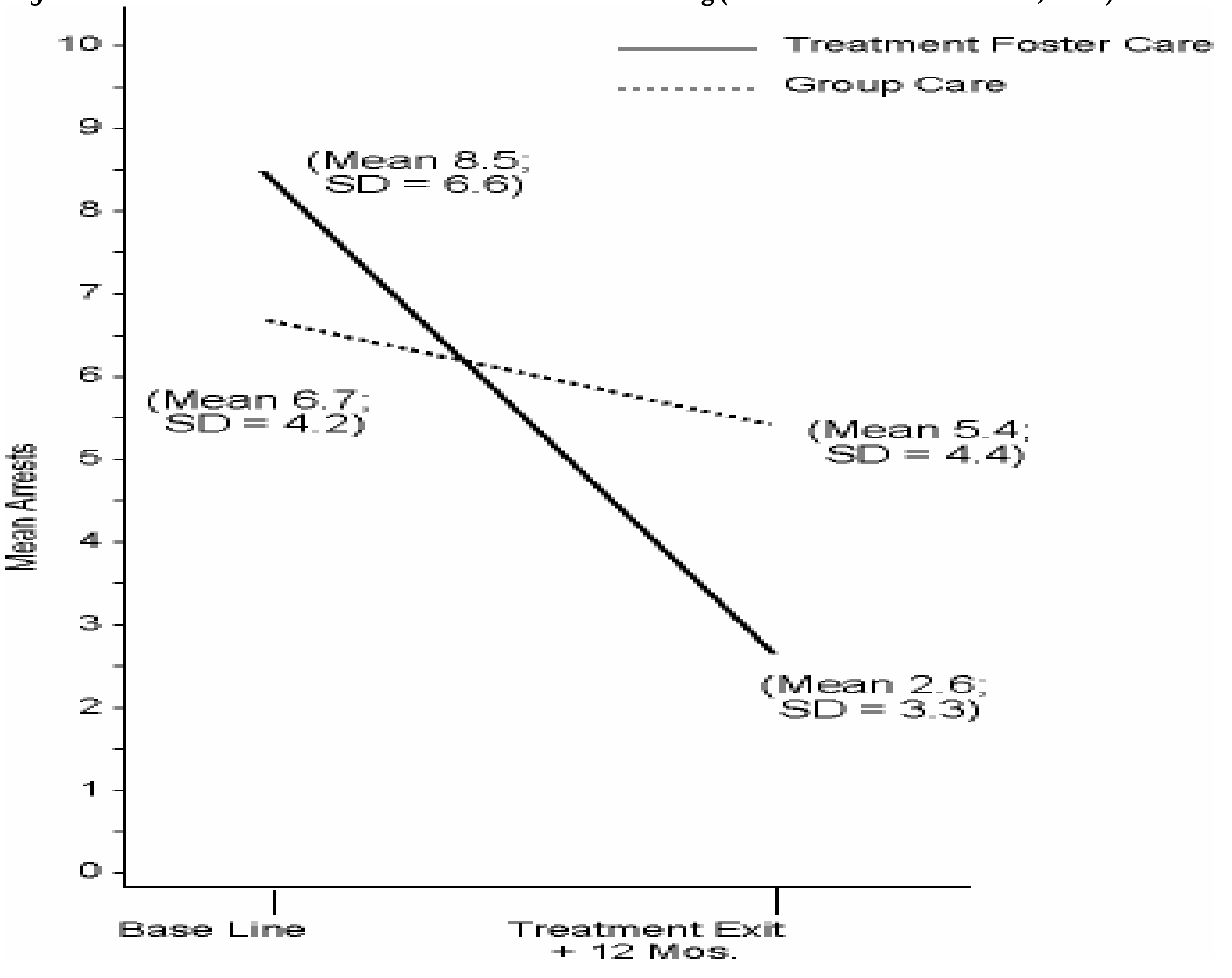
Figure 2. **Changes in observed child deviant behavior (from Patterson, Reid, & Chamberlain, 1982).**



showed significant changes from baseline to termination (Patterson, 1974a, b). The effect was replicated with the next 28 cases treated by a new group of therapists and observed by a newly trained set of observers (Patterson, 1979). We were pleased to find that slopes for the observed pre and post child deviancy scores from the two samples were nearly identical.

In the early 1970s, we designed studies that used randomized trials to demonstrate that the effects were due to effectively training parents and not some extraneous factors. The first study randomly assigned referred families to wait list control group or to an experimental group receiving PT procedures (Wiltz & Patterson, 1974). The observation data showed a significant decrease in the problem children's observed total deviancy score in the PT group and no change for the wait list control group. The next study randomly assigned participants to a placebo or a parent-training group (Walters & Gilmore, 1973). The placebo group involved leaderless group discussions. At the end of the trial, the parents' ratings showed that most of them perceived the placebo procedure was effective in decreasing child problems. However, the observation data showed the children were worse. Observation data showed the children in the parent-training group significantly reduced their rates of deviancy.

Figure 3. **Effect of foster treatment care on chronic offending (from Chamberlain & Reid, 1998).**



Finally, a sample of 19 cases was referred to either licensed private practitioners or to PT (Patterson, Chamberlain, & Reid, 1982). At termination, 70% of the boys in the experimental group functioned within the normal range, whereas 33% of the boys in the comparison group were in the normal range. Comparisons of the pre- and post-observed deviant behavior scores produced a significant group by phase interaction term.

In the studies that followed, most of the treated cases ranged in age from 4-12 years; the majority were from socially disadvantaged families. The intervention seemed more effective for younger as compared to older boys. The amount of time required varied a good deal, ranging from 4 to over 70 hours; with the average around 20 hours, including telephone calls and visits to the school. A study of cases referred for treatment by Phillips (1984) strongly suggests that limiting intervention to less than 20 hours increases the risk for treatment failure.

During the 1970s and 1980s, literally hundreds of studies were carried out examining the application of PT to children's antisocial behavior. A recent meta-analysis found an average effect size of .86 for these types of studies (Serketich & Dumas, 1996). Sanders and McFarland (2000) report similar levels of success in working with Australian families; and Tynan, Schuman, and Lampert (1999) found an effect size of .89 for preadolescent cases referred to a psychiatric community clinic.

We were pressured by the NIMH to apply the PT procedures to chronic offending adolescent delinquents (Bank, Marlowe, Reid, Patterson, & Weinrott, 1991). The sample was randomly assigned to intensive traditional community treatment or to PT. Prior to treatment, the adolescent boys averaged about eight offenses per individual. The families treated by therapists with several years of experience at the Oregon Social Learning Center (OSLC) averaged about 40 hours of professional time per family. The community group received about 50 hours. During the year following intervention, there was a significant reduction in police arrests for the boys in the experimental as compared to the community group. They also spent significantly less time in institutions over the 3-year follow-up. During the follow-up interval, both groups showed significant reductions in (nonstatus) offenses. The group-by-years interaction term was significant reflecting a larger drop for the experimental than for the control group.

Our treatment staff was convinced that the delinquency project, while a statistical success, was not an effective procedure for treating chronic adolescent delinquent children. It remained for one of the original therapy staff, Patricia Chamberlain, to develop a more feasible approach (Chamberlain & Reid, 1998). In this approach, adolescent chronic offenders were placed in foster homes in which the foster parents have been carefully selected, trained (in PT procedures), and supervised (on a daily basis). All boys attended public school. As the adolescents adapted to the highly structured environment they were returned to their biological families for brief intervals. During this stage the biological families received training and supervision in PT procedures. The details of the program were outlined in Chamberlain (1994).

The first study--a random assignment design--involved 79 boys, 12-17 years of age, referred for community placement. They averaged 14 previous referrals. The boys in the comparison group were placed in Group Care (GC) facilities characterized by variations of positive care philosophy. In those settings, each residence contained 6 to l6 boys. Most of them participated in group therapy sessions, and many also participated in family therapy with their biological parents.

As shown in Figure 3, there were reductions in offending for both groups. However, the reductions were significant for the group receiving Treatment Foster Care (TFC) but not for the GC group. The data also showed significantly less time spent in institutions for the TFC group. Currently, the program is being evaluated in several different locations. Most of us at OSLC believe that for chronic adolescent delinquents, TFC is far more effective than PT alone.

If one has an empirically based theoretical model and an empirically based intervention, then it should be possible to mount effective prevention trials. As noted earlier, there are now four prevention trials that employ PT procedures, five if one includes the Montreal project. In each of these at-risk samples, training parents in more effective practices produced long-term changes in future risk for antisocial behavior. Askeland, Duckert, & Forgatch (in press) and her staff completed a 2-year training program for 30 therapists working with families in Norwegian community clinics. This generation of therapists is currently training a new cadre. A randomized trial design is being used to evaluate the program.

Four decades of empirical studies provide a solid beginning for understanding the etiology and interventions for children's antisocial behavior. We have a good understanding of the key contingencies involved in children's aggression. We also have at least a partial understanding of who provides the reinforcers and in what settings. The theory about etiology is closely tied to the means for effective intervention. The close tie between theory and practice gives additional strength to the framework. Also, information from etiology and intervention studies can be used to design effective prevention trials. We now understand that experimental manipulations embedded in prevention studies can serve the useful purpose of testing for causal status of key mechanisms in the theory. This, in turn, implies that we may be in a position to move from a correlation-based science to one based upon experimental manipulations.

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Human Sexual Arousal: A Modern Behavioral Approach

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Recent developments in the analysis of derived relational responding have contributed to the behavioral analysis of a wide range of complex human behaviors, including sexual behaviors. In particular, recent research has demonstrated that human sexual arousal patterns can emerge in the absence of a history of instrumental learning or stimulus association. These findings considerably expand the traditional behavioral approach to the analysis of human sexual arousal. The current paper provides an overview of the traditional behavioral approach to the analysis of sexual arousal, and outlines Relational Frame Theory as a modern behavioral approach to human language, cognition, and complex behavior in general. A relational frame approach to the analysis of human sexual arousal is then outlined and its interpretative power in dealing with a range of complex human sexual behavior is demonstrated.

Behavioral psychology has not been particularly concerned with providing an account of human sexual responding, or with analyzing the emergence and maintenance of complex patterns of human sexual arousal. Although there has been limited applied research into the treatment of sexual dysfunction, basic research into the emergence and maintenance of sexual arousal patterns has been sparse by any standards. Nevertheless, over the past four decades behavioral researchers have established that sexual arousal can be conditioned using respondent (Barlow, 1993; Barlow & Agras, 1973; Barlow, Agras, Leitenberg, & Callahan, 1972; Conrad & Winzce, 1976; Herman, Barlow, & Agras, 1974; Kantorowitz, 1978; McConaghy & Barr, 1973; Plaud & Martini, 1999; Rachman, 1966; Rachman & Hodgson, 1968) and operant procedures (Bancroft, 1969; Barker, 1965; Crawford, Holloway, & Domjan, 1993; Earls & Castonguay, 1989; Mandell, 1970; McConaghy, 1969; McConaghy, 1970; McGuire, Carlisle, & Young, 1965; McGuire & Valance, 1964; Quinn, Harbison, & McAllister, 1970; but see O'Donohue & Plaud, 1994, for some caveats).

Recent advances in the analysis of complex behavior, and verbal behavior in particular, have further extended the conceptual and methodological armory of the behavioral sex researcher. More specifically, Relational Frame Theory (RFT; Hayes, 1991; Hayes, Barnes-Holmes, & Roche, 2001; Hayes & Hayes, 1989) has provided a conceptual framework for the analysis of the phenomenon of derived stimulus relations in an attempt to explain the emergence of language effects (e.g., generativity) and related cognitive phenomena. In so doing, RFT has demonstrated that a variety of complex and novel human performances can emerge from verbal contingencies. Relational frame research has also provided exciting analyses of the emergence of sexual stimulus functions for stimuli that have neither been associated with unconditioned sexual stimuli, nor served as discriminative cues for the availability of sexual reinforcement. In effect, a relational frame approach explains sexual arousal patterns that involve more than a history of respondent or operant conditioning alone.

In the current paper, we will provide an outline of behavior analytic sex research to date. We will then briefly outline Relational Frame Theory as an approach to derived stimulus relations, verbal behavior, human cognition, and complex behavior more generally. We will then outline recent RFT findings which suggest that the emergence of human sexual arousal may involve process other than those posited in a traditional classical or operant conditioning account. The interpretive power of the relational frame approach to human sexual responding will also be demonstrated. Finally, we will describe how RFT may shed light on the relationship between predispositions to sexual behavior and the emergence of complex and novel sexual arousal patterns established through learning histories.

BEHAVIOR ANALYSIS AND SEX RESEARCH

Respondent Conditioning

Binet (1888) proposed the first "classical conditioning" model of sexual arousal, which suggested that sexual responses might be partially determined by previous stimulus associations. It was not until the 1960s, however, that Binet's ideas were investigated in any serious way. In one study, Lovibond (1963) demonstrated that electrodermal responses of homosexual males could be conditioned, using film clips of nude males as unconditioned stimuli (USs) and abstract symbols as conditioned stimuli (CSs). This finding was further investigated by Rachman (1966) using genital measures of arousal. In this, by now famous study, a conditioned sexual response was established in male volunteers (measured using a penile plethysmograph) to a pair of female boots by repeatedly projecting slides of the boots on a screen immediately prior to the presentation of slides of "attractive" nude females. This "laboratory induced fetish" generalized to physically similar stimuli and extinguished with repeated presentations in the absence of the USs (i.e., the nude females). In a replication of this study, Rachman and Hodgson (1968) controlled for the effects of procedural artifacts and replicated the earlier findings. In a later study, McConaghy (1970) demonstrated conditioned penile volume increases in two groups of heterosexual and homosexual males using film clips of nude females and males, respectively, as USs (the CS was a red circle in both cases).

These and several further demonstrations of conditioned sexual arousal suffered from methodological problems that make a clear interpretation of the data difficult (see O'Donohue & Plaud, 1994). However, a recent study by Plaud and Martini (1999) addressed many of these issues in a well- controlled demonstration of respondently conditioned sexual arousal using nine male undergraduate volunteers as participants. This study convincingly demonstrated that sexual arousal can indeed be established for arbitrary stimuli (i.e., a penny-jar) using classical conditioning procedures.

Operant Conditioning

Experimental analyses of operant processes in human sexual behavior are extremely sparse. In one early operant study, Quinn, Harbison, and McAllister (1970) used small doses of a cold-lime drink to reinforce minimal erectile responses to slides of nude females in a group of liquid-deprived homosexual males (dehydration was achieved through an 18 hr abstinence period and the administration of a powerful diuretic). By gradually increasing the minimum erectile response required for reinforcement, heterosexual responsivity was enhanced. These authors suggested that erectile responses are highly susceptible to reinforcement, although no follow-up studies appear to have been conducted.

Applied Research

The roles of respondent and operant processes in human sexual arousal have been more widely studied in the clinical setting. For instance, Barlow and Agras (1973) employed a respondent fading procedure to increase heterosexual responsiveness in three male homosexuals. Clients were presented with slides of "attractive" nude males to which penile responses were monitored. The fading procedure involved the superimposition of slides of nude females as soon as an erectile response was recorded. Subjects demonstrated a decrease in responsivity to same-sex models and an increase in responsively to opposite-sex models. This procedure has also been used to reduce sexual responsivity towards prepubertal children (Beech, Watts, & Poole, 1971; see also Laws & Marshall, 1990).

A technique known as covert sensitization involves instructing clients to imagine aversive stimuli (e.g., vomiting) at the onset of a sexual response to "inappropriate" experimental stimuli. The technique has been used to reduce sexual responsivity to same-sex models in a group of homosexual males (Barlow, Agras, Leitenberg, & Callahan, 1972; see also Barlow, 1993; Marshall, Laws, & Barbaree, 1990). Other researchers have successfully used salient aversive stimuli, such as pictures, to induce nausea directly (Mandel, 1970) or have administered nauseating substances such as ammonium sulphide (Colson, 1972) and valeric acid (Maletzky, 1973).

Behavior analytic sex researchers have also used orgasm as an unconditioned stimulus in conditioning procedures. Using a technique known as orgasmic conditioning, Conrad and Wincze (1976) monitored the sexual arousal of four homosexual males as they masturbated. Slides of nude females were then presented to clients moments before orgasm. After several months of therapy, all four subjects reported an increase in heterosexual impulses (although erectile responses did not clearly support this claim; see also Herman, Barlow, & Agras, 1974). Kantorowitz (1978) later demonstrated a clearer case of orgasmic conditioning in eight male volunteers from a non-clinical population, using physiological measures. In this case, however, subjects' verbal reports did not bear this finding out and the conditioning effects were disappointingly short-lived.

In one typical aversive conditioning study, Feldman and MacCulloch (1971) administered electric shocks to a group of male homosexuals during the final 0.5-s exposure to visual "homosexual" stimuli that were 2 s in duration. A subsequent decline in responding to nude males was recorded. In a more recent study, the administration of a noxious olfactory stimulus (ammonia) was successfully used to punish sexual responses towards children in a male pedophile (Earls & Castonguay, 1989). The reduction in responding was still significant one year after therapy had ceased. Marshall and Barbaree (1988) reported the use of a combination of electric shocks and noxious olfactory stimuli to eliminate "deviant" sexual thoughts in a group of pedophile outpatients. Although not particularly widespread, aversive conditioning techniques are still in limited use.

A MODERN APPROACH

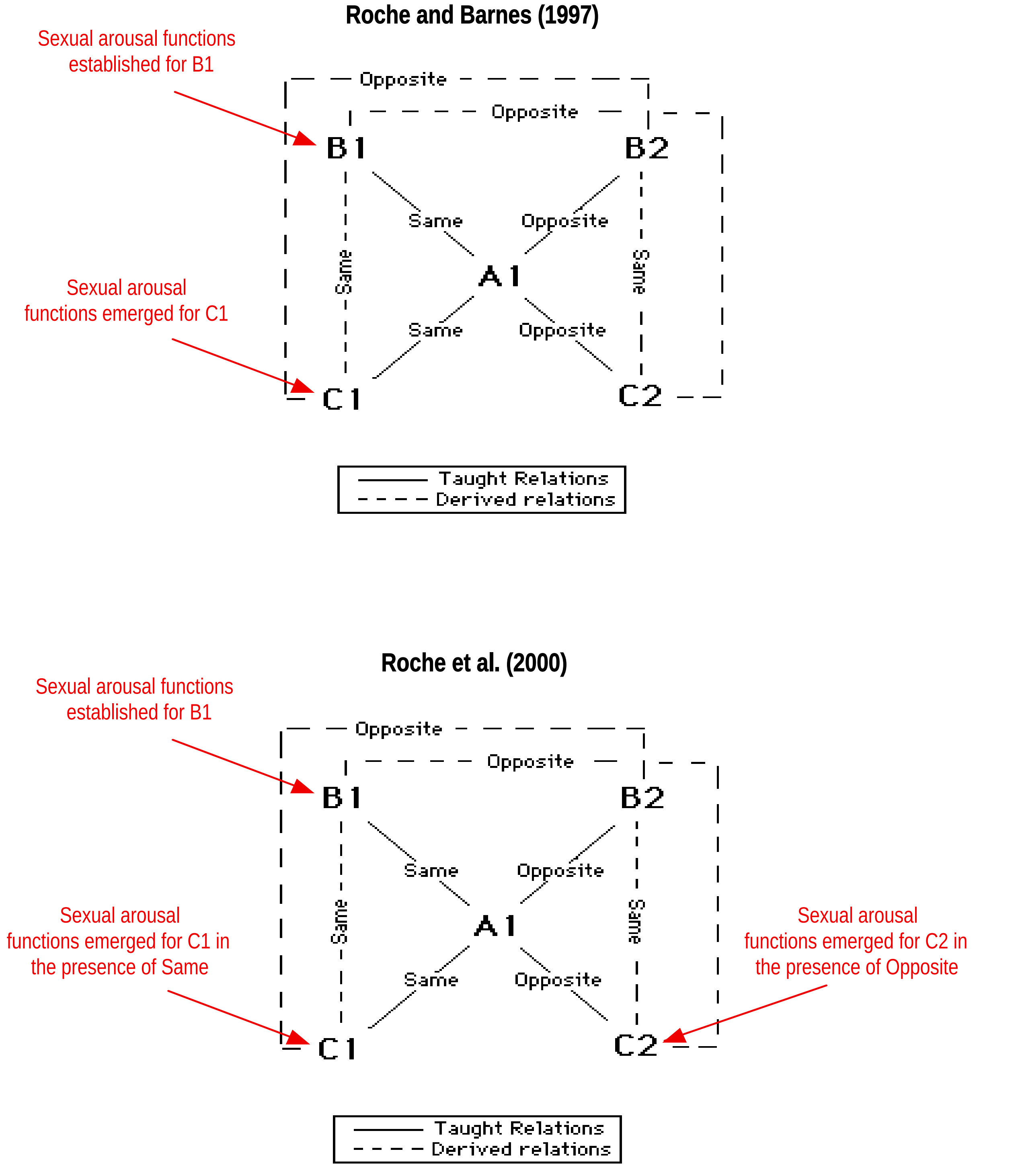
The basic and clinical sex research conducted to date within an operant or respondent framework has advanced our understanding of the etiology and maintenance of specific sexual arousal patterns. However, recent research under the rubric of Relational Frame Theory has extended the analysis of sexual arousal patterns to include instances in which sexual functions emerge for stimuli that have neither been associated with unconditioned sexual stimuli, nor served as discriminative cues for the availability of sexual reinforcement. Before we outline the relevant studies, we must first provide a brief outline of Relational Frame Theory as a modern account of derived relational responding, verbal behavior, human cognition, and complex behavior generally.

Perhaps the simplest derived stimulus relation is the equivalence or coordination relation. Specifically, when a subject is trained to match a stimulus A to B and to match B to C in a matching-to-sample (MTS) context, the subject will also likely match A to C and c to A without explicit reinforcement for doing so. This emergent performance defines the stimulus equivalence relation (c.f., Sidman, 1986; Sidman, 1990, pp. 100-102; see also Barnes, 1994; Fields, Adams, Verhave, & Newman, 1990). Furthermore, when a specific behavioral function is established of one of the stimuli in the equivalence relation, the function often transfers to the other stimuli without further training. For instance, if stimulus C in the foregoing example is paired with an aversive stimulus such as electric shock, then B and A may also acquire the fear eliciting functions based on their relation to C. This transfer of function effect has been demonstrated with discriminative (Barnes & Keenan, 1993; Barnes, Browne, Smeets, & Roche, 1995; deRose, McIlvane, Dube, Galpin, & Stoddard, 1988; Gatch & Osborne, 1989; Kohlenberg, Hayes, & Hayes, 1991; Wulfert & Hayes, 1988), consequential (Hayes, Devany, Kohlenberg, Brownstein, & Shelby, 1987; Hayes, Kohlenberg, & Hayes, 1991), and respondent stimulus functions (Dougher, Auguston, Markham, Greenway, & Wulfert, 1994; Roche & Barnes, 1997; Roche, Barnes-Holmes, Smeets, Barnes-Holmes, & McGeady, 2000).

Relational Fame Theory approaches stimulus equivalence as one of many possible derived stimulus relations. In fact, much empirical evidence now exists that human subjects can respond in accordance with multiple stimulus relations in the presence of appropriate contextual cues, such as difference, opposition, more than, and less than (Dymond & Barnes, 1995, 1996; Lipkens, Hayes, & Hayes, 1993; O'Hora, Roche, Barnes-Holmes, & Smeets, in press; Roche & Barnes, 1996, 1997; Roche, et al., 2000; Steele & Hayes, 1991). According to RFT, contextual control for relational responding is likely established during early language interactions. During these interactions children are often presented with objects and asked to repeat their names (e.g., "What is this?"). Children are also taught to identify objects when they hear the appropriate name (e.g., "Show me the ball"). Initially, each of these word-object and object-word relations is trained explicitly using a variety of reinforcers, such as food, verbal praise, and physical contact. Across such interactions however, derived relational responding may begin to emerge (i.e., in the absence of reinforcement). For example, a child with an extensive history of naming might be taught "This is your toy". Familiar contextual cues such as the word "is", and the context of the social interaction more generally, predict that if this object is a " toy ", a "toy " is this object. Thus, the child may now identify the toy when asked "Where is your toy?" in the absence of any prior differential reinforcement for doing so. In effect, the derivation of stimulus relations is not genuinely novel, but is a type of *generalized operant behavior* (see Barnes-Holmes & Barnes-Holmes, 2000, for an extended discussion). Put simply, once an individual has learned to derive stimulus relations, they can do so with an infinitely wide variety of particular stimuli.

Other types of stimulus relations, such as comparison, are also understood in terms of generalized operant behavior. Consider, for example, a young child who is taught to respond to a range of questions such as; "Which cup has *more* milk?" or "Which box has *more* toys?" Given sufficient exposure to such questions and appropriate reinforcement for answering them correctly, the appropriate response to the cups may come under the control of cues other than the actual relative quantities of milk in the cups (e.g., the word "more"). For example, a dime is *worth more than* a nickel, even though a dime is actually smaller in size than a nickel. As responses are brought under the contextual control

Figure 1: Trained and derived stimulus relations in Roche and Barnes (1997) and Roche et al. (2000).



of the appropriate cues (e.g., the word "more"), they become arbitrarily applicable. In other words, the child may eventually answer questions regarding relative quantity correctly, even with novel varieties of stimuli and in contexts where the appropriate response cannot be based on the formal properties of the stimuli involved (e.g., the relative value of coins). When this occurs a relational frame of comparison has been established.

Relational Frame Theory can be used in the analysis of individual relations or whole networks of derived relations. Relational networks help us to describe complex patterns according to which functions transform in the presence of particular contextual cues. Imagine, for instance, that we train the following network of derived relations; stimulus A *More than* stimulus B, B *More than* C, C *Same as* D (i.e., A>B>C=D). Now suppose that we use a respondent conditioning procedure to establish an aversive response function for D. Given the trained relational network, we will expect the aversive response function to emerge for C (i.e., because it is the same as D), but to be amplified for B (because it is More than C), and to be amplified further for A (because it is More than B and More than C). Several studies have demonstrated this type of complex derived *transformation of function* effect with operant and respondent functions (see Dymond & Barnes, 1995, 1996; Roche & Barnes, 1997; Roche, et al., 2000).

A NEW AGENDA FOR BEHAVIORAL SEX RESEARCH

If stimulus functions can be transformed by virtue of their participation in derived relations or complex relational networks, our understanding of the emergence of sexual arousal functions for arbitrary stimuli is immediately expanded. More specifically, the transformation effect should make it possible for an individual to respond sexually to a stimulus that has never been paired directly with an unconditioned sexual stimulus or used as a cue for the availability of differential sexual reinforcement. As a starting point for testing this idea, Roche and Barnes (1997) determined whether respondent sexual arousal functions could emerge for stimuli via the derived transformation of functions in accordance with an arbitrary relational network. In that study, Roche and Barnes (1997; Experiment 4) exposed three male and three female undergraduate subjects to a respondent conditioning procedure in which a sexually explicit and nonsexual film clips were paired with presentations of nonsense syllables B1 and B2, respectively. The conditioned response differential to B1 and B2 was measured with a polygraph.

Subjects were then exposed to a relational pretraining procedure to establish contextual functions of Same and Opposite for two arbitrary stimuli. Specifically, across several training trials subjects were presented with sample stimuli and three comparison stimuli that were related to each other along a physical dimension. For example, one set of comparison stimuli consisted of a long line, a medium line, and a short line. Given a short-line sample stimulus, in the presence of the Opposite contextual cue, choosing the long-line comparison stimulus was reinforced. However, given the Same contextual cue and a short line, choice of the short-line comparison was reinforced. With a sufficient number of such exemplars contextual control by the arbitrary cues was established and was evident across novel sets of samples and comparisons. In a subsequent training stage, a series of stimulus relations were trained in the presence of the contextual cues (see Figure 1), and a series of derived stimulus relations emerged during testing. As illustrated in Figure 1, the trained relations were; SAME/A1-B1, SAME/A1-C1, OPPOSITE/A1-B1, OPPOSITE/A1-C1. The derived stimulus relations were SAME/B1-C1, SAME/B2-C2, OPPOSITE/B1-C2, OPPOSITE/B2-C1.

During the critical probes for a transformation of function, subjects were repeatedly presented with the C1 and C2 stimuli, but in the absence of film clips. All three male subjects and one of the female subjects showed a transformation of the functions of the C stimuli in accordance with the relational network and the established respondent functions of the B stimuli (see Figure 1). More specifically, where sexual arousal functions were established for B1, they emerged for C1 but not C2 (i.e., both B1 and C1 are the Same as A1, and therefore the same as each other). Where sexual arousal functions were established for B2 they emerged for C2 but not C1 (i.e., both B1 and C1 are Opposite to A1, and therefore the same as each other).

A further study by Roche et al. (2000) replicated and extended the findings of Roche and Barnes (1997) by bringing the derived transformation effect under further contextual control. More specifically, during the critical probe stage the C1 and C2 stimuli were presented in the presence of each of the Same and Opposite contextual cues on different trials. The stimulus functions established for B1 emerged for C1 in the presence of Same (i.e., the subjects became aroused) but those established for B2 emerged for C1 in the presence of Opposite (i.e., the subjects remained relaxed). Similarly, the functions of B2 emerged for C2 in the presence of Same (i.e., the subjects remained relaxed), but those established for B1 emerged for C2 in the presence of Opposite (i.e., the subjects became aroused; see Figure 1).

The findings of Roche and Barnes (1997) and Roche et al. (2000) indicate that the study of derived stimulus relations has provided an opportunity to examine parameters of sexual responding that are not easily captured within a traditional respondent or operant paradigm. In particular, the transformation of functions in accordance with derived relations suggests that sexual arousal in the world outside the laboratory may sometimes arise in the absence of direct reinforcement or respondent conditioning. Thus, these findings significantly extend the existing behavioral literature on the development of sexual arousal patterns in humans.

Relational Frame Theory as an Interpretive Framework for Complex Sexual Behavior

From the RFT perspective, derived relations form the basis of language and cognitive skills in humans. Thus, some instances of human sexual arousal will depend upon verbal processes and will be controlled and maintained by verbal contingencies. The idea that human sexual arousal might emerge from verbal contingencies is not new. The feminist and sex research literature abounds with the suggestion that modes of discourse regarding sexuality both establish and constrain patterns of human sexual responding (see Brownmiller, 1985; Gergen, 1988; Segal, 1990). One language researcher (Lakoff, 1999), for instance, has suggested that the notably higher incidence of violent rape in the United States, compared to other countries, may be explicable, at least in part, by the way in which members of American culture talk about male sexual arousal by females. Specifically, some terms used to describe sexual arousal are aggressive and violent.

Roche and Barnes (1998) provided a detailed RFT interpretation of rape to explain how violent sexual responses may emerge from verbal contingencies for an individual who had never been exposed to explicit reinforcement for committing rape. Specifically, they suggested that many members of Western cultures are explicitly taught that, in the context of gender relations, males and females are “opposite” (e.g., members of “opposite” sexes). The authors further suggested that through interaction with popular culture, many children learn that women are submissive, whereas men are dominant (see Biglan, 1995, pp. 353-358; Guerin, 1994, pp. 283-287). In addition, the words “dominant” and “submissive” often participate in frames of coordination with the terms “a lot of control” and “lacking control,” respectively. Given that many individuals in the culture respond to these verbal relations, we might expect to find that many men are sexually attracted to submissive women or women that lack control.

In a suitable verbal or social context, some men may respond to the term “lack of control” as related to the term “no control” through a relational frame of comparison (i.e., greater than). When the relational network is expanded in this way, terms describing women may be equivalent to terms describing total submission or victimization. Consequently, verbal descriptions of powerless, submissive, or victimized women (e.g., in pornography) will elicit sexual arousal. This relational frame analysis represents the behavioral counterpart of the feminist idea that the basic elements of rape are present in the way women are often spoken of in the wider culture and presented in pornography (see Segal, 1990, p. 233).

If verbal contingencies can control sexual arousal patterns, even in limited contexts, we should expect to find that aversive conditioning techniques used to counter-condition deviant sexual arousal may leave the verbal contingencies governing arousal in tact. For example, an individual for whom rape urges have emerged partially from verbal contingencies, will continue to be exposed to those verbal contingencies even following an aversive therapy program. This may explain why the effects of aversive therapy for deviant sexual arousal are relatively short-lived (see Bancroft, 1969; Gosselin & Wilson, 1984; Maletzky, 1991; Marshall, Laws, & Barbaree, 1990; McConaghy, 1969; Rimm & Masters, 1979). Furthermore, the role of verbal contingencies in the establishment and maintenance of sexual arousal may explain why laboratory conditioned sexual arousal patterns lack the complexity to serve as a realistic model of human sexual arousal development in the world outside the laboratory (e.g., real-world fetishistic responses are extremely powerful and resistant to extinction; see

Bancroft, 1969; McConaghy, 1969, 1987; O'Donohue & Plaud, 1994).

Although many patterns of sexual arousal are surely established, at least in part, through direct reinforcement and respondent contingencies (see Brown, 1986; Wysocki, 1993), some sexual arousal responses seem to defy explanation in these terms. Bourget and Bradford (1987), for instance, attempted to explain the emergence of a fire fetish in two clinical patients. These researchers suggested that it would be difficult to account for the emergence of such a fetish in terms of respondent or operant processes. That is, it is difficult to imagine a situation in which fire reliably predicts the onset of a sexual stimulus or in which contact with fire is sexually reinforced (see also McConaghy, 1987, for a similar argument pertaining to transvestism).

Roche and Barnes (1998) provided a relational frame interpretation of a fire fetish in terms of the cultural/verbal relations to which particular individuals respond. That analysis suggested that both sexual arousal and fire are spoken of as "*explosive*" and "*hot*". In popular romantic literature lust is often referred to as "*burning desire*" and love as a "*flame*." In popular music, lyrics and song titles have contained phrases such as "*Come on baby light my fire* (The Doors)", "*Come on stand next to my fire*" (Jimi Hendrix), and "*Burning love*" (Elvis). Furthermore, under the reference term "fire", the Oxford English Reference Dictionary cites the terms*; fervor, vivacity, vehement emotion, stimulate the imagination or emotion, fill with enthusiasm*, and *become heated or excited*. Other frames of coordination and opposition between sex and fire in common parlance are apparent in common expressions recorded by Lakoff (1999). These include: "*I've got the hots for her*", "*She's an old flame*", "*She's frigid*" (a frame of opposition), "*She's hot stuff*", "*Don't be cold to me*" (a frame of opposition), "*He's still carrying a torch for her"*, "*She's a red hot mama*", "*I'm warm for your form*", and "*I'm burning with desire*". In effect, it would appear that relational networks established for many members of the verbal community involve frames of coordination between sexual arousal and fire, and frames of opposition between sexual arousal and coldness. Thus, we should expect to observe occasionally a transformation of the response functions of fire by those of sexual arousal.

Contexts that support the transformation of the functions of sexual arousal and fire have yet to be identified in laboratory research. However, these contexts must be severely limited by the natural contingencies governing contact with fire. More specifically, given that physical contact with fire is painful and life threatening, any transformation of the functions of fire by those of sexual arousal will likely be punished by sexual advances towards fire. It is hardly surprising therefore, that a sexual predilection for fire is so rarely recorded. Nevertheless, the fact that fire fetishes do occasionally emerge, despite the immediate physical contingencies that make it unlikely, bears witness to the considerable behavioral control exerted by verbal contingencies over sexual arousal patterns in humans.

Behavioral Predispositions and Pragmatic Verbal Analysis

Respondent and operant conditioning processes, as well as derived relational responding, likely play roles in the emergence of sexual arousal patterns in humans. Consequently, humans are capable of responding sexually to an almost infinite variety of stimuli, depending on prevailing contingencies. However, the RFT approach to sexual arousal explicitly acknowledges natural constraints placed on sexual conditioning by the physical forms of stimuli. Although entirely derived sexual responses to arbitrary stimuli may be established in the laboratory (e.g., Roche & Barnes, 1997; Roche et al. 2000), it is likely that many directly conditioned and derived sexual stimulus relations in the world outside the laboratory have some nonarbitrary properties. Indeed, researchers have long noted that natural selection has favored associations between specific types of stimuli and specific types of responses (see Garcia & Koelling, 1966; Seligman, 1970). For instance, Gosselin and Wilson (1980) reported a surprising consistency across stimulus types that form fetish objects for males; they are typically pink, black, smooth, silky, and shiny. These characteristics have been likened to those of the female vulva, suggesting a biological preparedness for conditioning to such stimuli (McConaghy, 1987). Conversely, it has been argued, other objects commonly associated with sexual arousal, such as pillows and ceilings, are rarely reported as fetish objects.

A relational frame approach proposes that formal similarities between stimuli will make a wide variety of derived relations between them more likely to emerge. As suggested by Roche and Barnes (1998), for instance, the physiological changes that occur during sexual arousal share many formal properties with the subjective experience of fire (e.g., perspiration, increased blood pressure, respiratory changes). In effect, the formal features of sexual arousal and fire facilitate the emergence of derived relations between them. In the case of sexual arousal and fire, this derived relation is one of coordination (i.e., they are similar, or "go together"). Thus, although a derived relation between sexual arousal and fire may in principle emerge from entirely arbitrary relational networks, the physical relationship between sexual arousal and fire may participate in the generation of those relational networks.

Although fire fetishism is likely partially based on the formal properties of sexual arousal and fire, it is unlikely that the formal properties are in themselves sufficient to account for the derived relation between fire and sexual arousal (e.g., radiators also produce heat but are not reported as fetish objects). In effect, while derived relations are arbitrarily applicable to any set of events (e.g., sexual arousal and fire) they are not arbitrarily applied. Instead, the application of derived relations between sexual arousal and other events is controlled arbitrarily by specific contextual cues (e.g., "she *is* hot"). By recognizing the subtle interaction between verbal and nonverbal learning processes, therefore, RFT provides a viable technical account of the emergence of highly complex and unusual sexual arousal patterns. This encompasses our knowledge of evolutionary variables, histories of direct stimulus association, instrumental learning, and the role of derived stimulus relations and verbal contingencies in the development of human sexual responding.

Conclusion

Our understanding of human sexual arousal has been expanded considerably by recent empirical and conceptual analyses of derived relational responding and its relationship to human sexual arousal. This research has shown that the human capacity for language impacts upon the emergence and maintenance of sexual arousal patterns. The control of sexual arousal by verbal contingencies increases the number of ways that sexual arousal may emerge beyond those posited in a traditional behavioral account of human sexual arousal. In addition, the RFT approach also speaks to natural constraints on sexual learning placed by the formal properties of the stimuli involved. Relational Frame Theory, therefore, promises to expand considerably the on-going behavior analytic contribution to human sex research in the field of psychology.

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EXPLAINING LANDSCAPE CHANGE: GROUP IDENTITY AND BEHAVIOR

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There is an ongoing need for behavior analysts to look beyond their conventional interests and to conduct research on the behavior of individuals as members of groups, and there is a corresponding need for other social scientists to take advantage of the established and growing body of concepts and principles developed by behavior analysts. One possible area of investigation concerns behavior that changes landscapes that groups occupy and that facilitates creation of regional landscapes. Both landscape change and regional landscape creation are general outcomes of behavior that are conventionally studied by cultural geographers, a group of scholars who have shown little interest in, indeed disdain for, behavior analysis. Notwithstanding the unfortunate precedent, the prospects for an integration of interests are encouraging. The concepts of rule-governed behavior and of delayed outcomes appear especially relevant.

Keywords: cultural geography, landscape, behavior, group identity, religion

Cultural geography, as one part of the larger discipline of human geography, is concerned with relationships between people and place. For example, cultural geographers focusing on historical topics are interested in human behavior and related landscape change and regional landscape creation. One research question might be: Why did Mormon settlers choose to venture significantly beyond the American frontier in 1847 and settle in an area that most contemporary Americans regarded as inappropriate? Another question might be: Why did British settlers in southeastern Australia move from the established coastal region to initiate a pastoral economy beginning in the 1820s? Answers to questions such as these usually refer to specific contexts of people and place. Thus, Mormons moved from Nauvoo, Missouri, to the Salt Lake region to enhance group identity and facilitate creation of a Mormon place, while pastoral expansion in southeastern Australia was related to the interest in occupying land suited to wool production.

Behavior analysts will recognize that these examples of cultural geographic questions are about human behavior, albeit at a group scale, and that behavior analytic concepts and principles might be relevant in seeking answers. However, as discussed in an earlier paper in this journal (Norton 2001b), research along these lines is atypical in the context of a cultural geography subdiscipline characterized by subjectivist approaches. Written for an audience of behavior analysts, this paper aims to encourage researchers to expand their horizons to include studies of behavior normally of interest to cultural geographers on the grounds that behavior analysts are particularly well equipped to provide explanations and insights. Of course, cultural geographers are being encouraged to apply behavior analytic concepts and principles in their studies (for example, Norton, 2000). Expressed rather differently, for both groups of scholars, the aim is to suggest the value of a behavior analytic informed research agenda for cultural geography.

The paper is organized into four sections. First, there is a brief review of selected concepts introduced by cultural and historical geographers that are implicitly behaviorist. Second, two analyses that are explicitly behaviorist are briefly noted. Third, group identities and the landscapes groups occupy, value, and change are further discussed with reference to behavior analytic concepts and principles. An optimistic, but admittedly uncertain, final section appraises the prospects for a cultural geography informed by behavior analysis.

Some cultural geographic concepts

It is possible to identify many instances of cultural geographic research that have behaviorist overtones, but few that are explicitly based on the logic of behavior analysis. Seminal work by Sauer (1925, 1941), the doyen of American cultural geographers, has been interpreted as behaviorist because of the focus on culture as learned behavior, because of the interpretation of culture as cause of landscape change, and because of the claim that cultural groups strive to maximize satisfactions and minimize effort. However, cultural geographers who worked in this tradition chose neither to discuss a behaviorist philosophy nor to employ behavior analysis, although many of the concepts used are implicitly behaviorist. Four closely related concepts are discussed.

A first concept is *first effective settlement*, asserting that: “Whenever an empty territory undergoes settlement, or an earlier population is dislodged by invaders, the specific characteristics of the first group able to effect a viable, self perpetuating society are of crucial significance for the later social and cultural geography of the area, no matter how tiny the initial band of settlers may have been" (Zelinsky, 1973, p. 13). The logic of first effective settlement is often used in accounts of cultural landscapes. In the case of the Musconetcong Valley landscape of New Jersey, for example, many elements reflect continuity from the eighteenth-century pioneer period to the present; thus, houses and barns along with many auxiliary structures reflect types established in the area during the eighteenth century (Wacker, 1975).

A second concept is *authority of tradition*, referring to the idea that, notwithstanding the impacts of technological and other change, it continues to be usual for landscapes to be constructed in accord with established initial regional cultural traditions. Hudson (1994, p. 3) noted this idea in an account of the formation and shaping of the American corn belt as it related to cultural hearths in the east, specifically the Upland South, an area stretching from southeastern Pennsylvania to eastern Georgia. The authority of tradition is clearly evident in many contemporary American landscapes, especially agricultural landscapes.

A third concept is *preadaptation*. This idea was introduced by Newton (1974, p. 143) in an attempt to explain diffusion of culture from the American Upland South to cover much of the United States as far west as the plains. Preadaptation involves a culture that already possesses necessary cultural traits to allow successful occupation of a new environment prior to movement to that environment; groups with these characteristics have a competitive advantage. The argument is that preadapted settlers were necessarily effective settlers, and hence, if they were first arrivals in an area, they established the first effective settlement. The most fully developed argument along these lines noted the role played by seventeenth century lower Delaware Valley Finns who, because of their previous European experience, were preadapted to life on the American frontier. As such, this group can be seen as the single most important contributor to the culture of the American backwoods frontier (Jordan & Kaups, 1989).

A fourth concept is *culturally habituated predisposition*. This is the idea that, for reasons of cultural tradition and preference, groups of people favor one particular use of landscape. The American corn belt, for example, can be understood as the "landscape expression of .... the totality of the beliefs of the farmers over a region regarding the most suitable use of land in an area" (Spencer and Horvath, 1963, p. 81).

In addition to these concepts, Lewis (1979) proposed a set of seven axioms and related corollaries as guides to aid the understanding of landscape formation. Together, these propose that human-made landscapes are intimately related to the physical environment, and that they provide strong evidence as to who the occupants of a region were in the past and are today.

The behaviorist content of these various ideas is evident, with the recurring suggestion of repetitive behavior and modeling. Individuals are understood to be behaving in accord with established group practice, given that previous behavior has proven reinforcing. Further, the groups concerned are cultural groups, informally defined on the basis of ethnicity, religion, language, and location of previous residence. The fact that cultural geographers introduced these implicitly behaviorist concepts and axioms indicates a general appreciation of the behavior analytic concept of operant conditioning.

Australian squatters and American Mormons

Two studies, one concerned with the nineteenth century southeastern Australian pastoral frontier (Norton 1997) and one concerned with the nineteenth century American intermontane west frontier (Norton 2001a), explicitly employ the concepts and principles of behavior analysis. This section situates these studies within the broader context of frontier expansion and landscape change, anticipating the research proposals included in the following section.

Pastoral squatters in southeastern Australia and Mormon settlers in the American intermontane west selected new locations and created new landscapes in accord with their particular worldviews. In both regions, distinctive and relatively coherent landscapes emerged. Settlers with different ideologies colonized two different places, and hence different landscapes evolved. But a fundamental similarity is evident in that landscapes in both areas displayed a high degree of regional uniformity. Regardless of the regional context, individuals behaved as members of groups wishing to achieve progress.

Australian frontier expansion involved larger areas, fewer people, and a less sedentary way of life than was the case in the United States. Grocott (1980) characterized the Australian frontier as a primitive environment with a society that was "harsh, struggling, masculine, materialistic and irreligious" such that "survival took precedence over religion" (p. 217). In the United States, much initial migration was of religious groups persecuted in Europe, and a sustained religious enthusiasm allowed Methodists and Baptists to achieve rapid and considerable growth. Numerous new sects appeared on the frontier, with one of the most successful being the Mormon church, the members of which, it can be argued, survived because of their religion. In both regions, individual group members practiced predictable and similar behavior. This circumstance is explained by the fact that, in each case, group members faced a common physical landscape and had a shared ideology.

For the southeastern Australian squatter, the physical landscape was an extensive semi-arid and gently rolling grassland area. The prevailing ideology after about 1820 included “little interest in colonial lands except as improved pastures for speculative wool growing, and an identification of pastoral prosperity with world market conditions at the expense of local market diversification” (McMichael, 1984, p. 146). This ideology was unaffected by religion because of weak religious infrastructure throughout the region and paucity of religious variation. In short, economy and religion were separate concerns in southeastern Australia.

A very different situation prevailed in the semi arid intermontane west where settlement opportunities were limited to valley bottoms. In this region, Mormonism conditioned all aspects of the worldview. After 1847 Mormon settlers gathered well beyond the American frontier in order to be together and to contribute to creation of their place. Specific settlement decisions were made in response to requests from church leaders, such that the occupation of the area followed an essentially orderly sequence in accord with larger church concerns and ambitions.

Despite these substantive differences of place and people it is clear that, in both regions, individual behavior was in accord with established group goals, such that localized cultures created regional landscapes. Accordingly, both examples have been studied using the concepts and principles of behavior analysis. These studies employed the basic logic of operant conditioning, and also the concepts of metacontingency, rule-governed behavior, delayed reinforcement, and establishing operations.

Identity and landscape

People and place relationships

This phrase was included at the outset of this paper in an attempt to capture the spirit of a cultural geography interested both in group identities and in the landscapes that groups occupy and change. Much contemporary cultural geography studies these relationships from a variety of subjectivist procedures, many of which link to cultural studies and focus on perception and symbolism, but they can be more effectively studied. Given the several relevant ideas developed by cultural geographers, and given the two specific examples noted above, behavior analysts will not be surprised to hear that there is significant potential for this cultural geographic subject matter to be studied using behavior analysis. Broadly speaking, much of our behavior in landscape can be understood through a judicious application of behavior analytic concepts and principles. In this section the focus continues to be on the general issue of relationships between group identities and the character of the places that groups occupy and create.

Cultural geographers pay much attention to a simple fact—as cultural groups adjust to their physical environment, they stamp it with their cultural impress, such that the presence of distinctive regional landscapes stands as testimony to the importance of cultural identity as a formative factor in this process. The literature of American cultural geography is replete with examples of regionally distinctive landscapes formed by individuals as members of cultural groups. The Mormon example may be especially compelling, but it is only one example. Examples of other well recognized regions include New England, Appalachia, the South, French Louisiana, the corn belt, the Great Plains, Texas, Hispano New Mexico, eastern Colorado, the Willamette Valley, northern California, and southern California. In each case, it is possible to identify, with varying degrees of precision, a distinctive group of people who practiced relatively uniform behavior in an essentially similar physical environment to produce a regionally distinctive landscape. It is this regularity of landscape evolution that invites application of behavior analytic procedures. But, precisely how is such an analysis to proceed?

Accounts of a physical environment (climate, landforms, soils, and vegetation), of a cultural environment (religion, language, ethnicity), of an economic environment (for example, capitalism or socialism), and of a technological environment (for example, agriculture or industry), are accounts of antecedent conditions. A physical environment typically serves as a discriminative stimulus, a cue informing people what to do in order to get what they already want. Cultural, economic, and technological environments are better described as establishing operations in that they motivate particular behaviors in landscape. The decisions that people make are operants resulting in consequences. If the consequences are culturally satisfying and economically successful, then they reinforce the behavior. However, these reinforcers are not usually direct-acting because the outcomes are typically delayed. In such circumstances, there will normally be direct-acting contingencies relating to the statement of rules that specify the consequences of behavior, and individual behavior will normally involve imitating the behavior of others. Thus, much of the behavior responsible for the transformation of landscapes is a form of rule-governed behavior. Further, a particular economic activity qualifies as a cultural practice, and the group of individuals comprising a group function as a permaclone. Finally, there is a metacontingency, namely an environmental context, a set of behaviors, and consequences that make the continuation of the set of behaviors probable.

Particularly interesting is the situation where individuals readily understand themselves to be members of a group. Such a situation is usual as individuals tend to identify with others who are similar. Although religious groups are perhaps the most obvious examples, it seems clear that religious behaviors are not meaningfully different from other behaviors in the sense that much of our behavior is socially controlled. Behavior analysts interested in group behavior acknowledge this circumstance (Nevin, 1997; Guerin, 1998; Houmanfar, Hayes, & Fredericks, 2001).

For religious and other closely knit groups, there are likely to be two sets of antecedent conditions. First, there may be an explicit or implicit hierarchical administrative structure with members typically responding to requests from leaders. Second, group members may practice cooperative effort and offer support to other members. These antecedent conditions, better understood as establishing operations, prompt groups to formulate rules to guide behavior. There are also delayed consequences that encourage individuals to behave in accord with requests from leaders and as members of a community. Further, there are usually direct-acting contingencies that relate to rule stating: for example, the fact that commitment to a religious faith is shared with others reinforces decisions. Overall, direct-acting contingencies encourage group members to keep emitting accepted behavior until reinforcing consequences specified by rules come into play.

Many cultural geographic studies of religious groups in landscape implicitly recognize the role played by adherence to cultural norms; that is, the presence of rule-governed behavior. Consider the behavior analytic implications of the following comment about members of the Dutch-Reformed church in southwestern Michigan. According to the cultural geographer, Bjorklund, (1964):

> *The basic principles followed by the adherents to Dutch-Reformed ideology can be stated simply as follows: (1) there are particular rules governing the conduct of life which must be obeyed literally; (2) man is obliged by these rules to perform both physical and spiritual work; and (3) opposition or intrusion of conflicting rules of conduct cannot be tolerated, because life after death depends upon the literal conduct of life on earth on a principled basis and is not subject to individual interpretation (p. 228).*

Given these three principles, it is not difficult to envisage a behavior analysis of the Dutch-Reformed settlement experience in southwestern Michigan.

For cultural geographers, it is the visible landscape that is the most interesting consequence of behavior. Uniformity of behavior leads to the formation of a landscape that is homogeneous—indeed, this is precisely what cultural geographers understand by the term, region. Two examples of cultural groups, the regions they occupy, and relevant landscape features help clarify this point.

In the case of the Mormon landscape, Francaviglia (1978) identified some distinctive features that are absent in the surrounding areas, and attributed these features to the character of the cultural group. A key landscape feature during the nineteenth century was building of towns in preference to dispersed agricultural settlement, with these towns laid out on a regular grid pattern and oriented to cardinal compass points. There were square blocks, wide streets, lots as large as two and a half acres that included backyard gardens, use of brick or stone construction, and central areas for church and educational buildings. These features were included in the original plan of the ‘City of Zion’ as detailed by the first Mormon prophet, Smith, in 1833. Arable agriculture dominated rural landscapes, and was supported by a network of irrigation ditches. Irrigation was necessary because the area settled was typically semiarid, unable to support arable agriculture without irrigation, and also because the desired Mormon way of life required arable agriculture. The combination of these various features clearly distinguishes the Mormon landscape as a cultural region.

The Hispano New Mexico region is regionally distinctive because of the presence of long lots, irrigation systems, adobe buildings, outdoor ovens, village settlement with plazas, and the profusion of Spanish and religious place names (Nostrand, 1992). Again, the presence of each feature is explained by reference to the character of the cultural group, and in this case many of these features were evident earlier in Spain and New Spain. Settlers built adobe buildings, a reflection of the shortage of timber for building purposes, in the favored floodplain areas. To accommodate additional family members, houses were frequently added to over time resulting in L-shaped or even U-shaped forms. There are also homes built of stone while, in the upland areas, log buildings are usual. Early villages comprised either houses on small lots around a plaza, or rows of houses on lots along a riverfront. The latter form was especially popular after about 1850 when defense was less of a consideration. The impress of religion is striking, with Catholic churches, shrines, and religious meeting houses being characteristic features of the landscape. The religious meeting houses, moradas, of Penitente chapters are of especial symbolic importance. Spanish, often religious, place names are usual throughout the landscape and provide an especially compelling aspect of the regional identity.

Expanding horizons

The challenge is real and considerable. Behavior analysts need to vigorously assert the relevance of their procedures to new audiences, while members of those audiences already committed to these procedures need to demonstrate their relevance both conceptually and empirically. Behavior analysts need to pursue the ambitious agenda established by Homans (1987) to the effect that the propositions of behavioral psychology are the general explanatory propositions of all the social sciences. Cultural geographers need to reconsider the current infatuation with cultural studies and the related neglect of objectivist procedures.

The emphasis in this paper is on core subject matter of much cultural geography, namely, group identity and formation of regionally distinctive landscapes in areas settled by groups. It is suggested that behavior analysis has much to contribute to these cultural geographic analyses. But prospects for contributions are not restricted to this subject matter, as the following brief reference to studies of ecology suggests.

Given that much behavior is best understood in terms of benefits that individuals experience through their participation as members of groups, many environmental dilemmas we face today might be appropriately addressed if we act in accord with group rather than individual interests. This is to say no more than was said by Hardin (1968), when he introduced ‘The Tragedy of the Commons,’ or than was said by Gould (1990), when he referred to ‘The Golden Rule’ as the key principle for maintaining a sustainable world. It seems likely that individual appreciation of shared goals might prompt individual behavior that is environmentally friendly because of concern for others. Hutcheon (1996, xii) noted: “It seems clear that, with the achievement of an authentically *scientific* study of individual development and social relations, humankind would for the first time have the capacity to adapt in a disciplined and reasoned way to the problems thrown up by the ever-changing circumstances of our existence.”

The more each of us behaves in accord with such fundamental principles as those expressed by Hardin and Gould, the better will be the world in which we live. Many religious beliefs claim that they incorporate a conservationist environmental ethic, but few have been able to exercise the necessary meaningful control over individuals that might lead to more environmentally friendly behavior than is currently being practiced. Ideas about social control are among the most controversial claims made by those who subscribe to the philosophy of radical behaviorism. Nevertheless, this idea has contributed to the rise of the important field of applied behavior analysis, one aim of which is to help people to behave in ways that have long-term benefits for all humans. For Skinner, a principal goal was that of improving our quality of life, and there is no doubt that environmental issues are central to our collective well being at the present time.

Proposals for new directions mean little unless they are both supported by applications and adopted by other researchers. The value of the proposals included in this paper is already evidenced by the examples of the studies of nineteenth-century Australian squatters and American Mormons. The author of this paper intends to continue investigations along these lines and hopes that others are encouraged to pursue and expand these ideas.

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CAN'T JANE READ OR WON'T JANE READ? AN ANALYSIS OF PRE-READING SKILLS DESIGNED TO DIFFERENTIATE SKILL DEFICITS FROM PERFORMANCE DEFICITS

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This single-student experiment demonstrated a method for assessing a student's poor performance on pre-reading measures that tested skill deficit and performance deficit hypotheses. This assessment was conducted for a student whose parents reported concerns regarding a variety of indicators of school functioning. During the summer prior to his entering first grade, his letter name knowledge, letter sound production, and Dolch word recognition were assessed. The assessment was conducted in a multiple baseline across the three reading tasks. Rewards and instruction were introduced sequentially across the three sets of reading materials. The results supported a combination reading skill and performance deficit hypothesis for the student. The assessment identified procedures that resulted in a substantial increase in reading fluency for these tasks. Procedures are adaptable to the needs of teachers, psychologists, and other education professionals who wish to determine whether reading problems result from poor skills or poor motivation.

Teachers, school psychologists, and other school practitioners are constantly faced with the learning problems of students who do not complete academic tasks or perform desired behaviors. These include a wide range of behaviors, from strict academic tasks such as division facts to school survival skills such as turning in assignments. Although it may be clear that the behaviors are not performed, it is often unclear whether the student does or does not know how to perform the skill. This study was conceived with the goal of designing a method for sorting these questions for students with academic problems.

Skill deficits and performance deficits were originally proposed as classifications for social incompetence in children (Gresham, 1981). Within this system, a social behavior problem is classified as a *skill deficit* when the child does not have the skill required to perform a given social behavior. For example, Jack begins kindergarten in September. He is an only child who lives far from town and has not had the opportunity to play with other children. Jack's teacher notices that during recess, Jack does not play with the other children on the playground. When Jack's mother explains the situation to his teacher, his teacher suspects that Jack may not know how to ask the other students to join their game. She decides to show him how this is done and practice with him before going onto the playground the next day. On the other hand, a child who has been observed performing a particular social skill but does not do so under the conditions demanded by the situation is said to have a *performance deficit*. For example, after Jane's family has moved to a new school, her teacher reports to her parent that Jane does not play with the other children during recess. Jane's father replies to the teacher that Jane played well with other children in her last school. In this case, it is possible to determine that Jane has the requisite skills to play with others but has not used them in this new environment. Jane's teacher determines that the problem is a performance deficit and decides to ask other students to invite Jane to play during recess.

Although these skill and performance deficit classifications were originally developed to describe problems in social competence in children, the concepts can be extended to describe problems in academic competence (Noell, Witt, Gilbertson, Ranier, & Freeland, 1997). An academic problem identified by a school practitioner would be described as a skill deficit when that skill had not been learned by the student in spite of instruction. The academic problem would be described as a performance deficit when, despite having observed the student perform that skill in another situation or at another time, the student does not perform the skill sufficiently to be considered competent according to the standards determined appropriate for that material.

This study was designed to examine a method

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for analyzing pre-reading skills that was derived from the skill deficit and performance deficit hypotheses described above. Pre-reading skills were selected as the target for assessment as they are the building blocks for a variety of reading outcomes such as oral reading fluency, comprehension, phonics skills, and vocabulary (Marston, 1989).

Several authors (Fuchs & Deno, 1982; Lovitt & Hansen, 1976; Shapiro, 1990) have recommended the use of oral reading rates obtained through standard Curriculum Based Measurement (CBM) procedures to identify instructional level materials for children. However, not all students will work to the best of their ability when they are assessed. For these students, the oral reading rate will be an underestimate of skills. In addition, for students who do not yet read words presented in story or paragraph form, standard procedures for assessing letter name knowledge and letter sound production have not been tested.

This study used the basics of CBM procedures with the addition of reward and instruction to create assessments for letter name knowledge, letter sound production, and for Dolch word recognition. These assessments tested for the possibility that poor reading on these tasks could be described as either skill or performance deficits. If a student's letter identification improved as a result of a reward for letters identified correctly, the hypothesis would be adopted that the low rate was a performance deficit. If letter identification improved due to instruction, but not reward, the skill deficit hypothesis would be adopted. An important benefit of the method would be that if the procedure worked with a student, it would serve to identify an intervention that would help the student succeed with that skill.

METHOD

Participants and Setting

John, a six-year-old boy, was participating in a three-week summer program for children with Attention Deficit Hyperactivity Disorder. He was scheduled to enter first grade in the fall following the summer program. John's parents had reported concerns regarding reading skills (recognizing words), math skills, social skills, and behavior outbursts. The summer program staff had collected CBM data for all participants prior to the start of the program. John read 0 words per minute in first grade materials. Based on this information, naming letters, producing correct letter sounds, and recognizing Dolch words were chosen as target skills for John. All sessions were conducted in the classroom where the summer program was housed with the tester and John seated opposite one another at a desk.

Materials

Letter names and letter sounds. Seven different test sheets were composed to test letter names and letter sounds. For each sheet, all 26 capital letters and 26 lower case letters were listed in a different random order. The letters were spaced evenly across each page, with 5 letters in each line except for the last line.

Dolch words. The standard Dolch 110 word list was used to create seven different word list test sheets. For each sheet, 50 words were randomly selected. Words were spaced evenly across each page, with 5 words in each line.

Skills and Measurement

Letter names or sounds. Letters named and letters sounded were defined as letters read or sounded correctly with no more than a 3-s delay after the completion of the preceding letter. Letter sounds produced or letters named were marked correct or incorrect on a second copy of the test sheet as John read aloud.

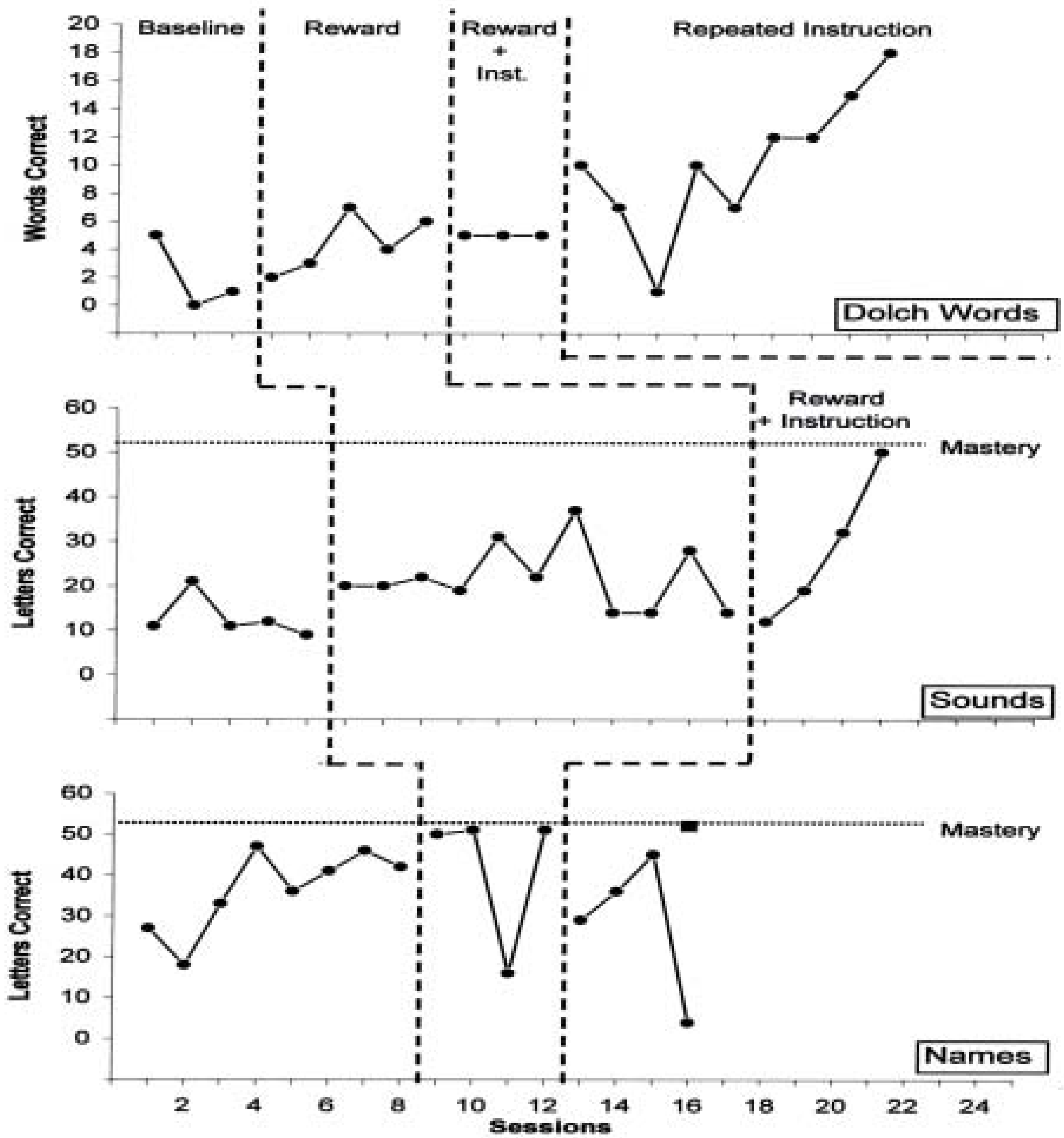
Dolch words. Words read was defined as words read correctly with no more than a 3-s delay after the completion of the preceding word. Words were marked correct or incorrect on a second copy of the test sheet as John read aloud.

Interobserver agreement. A second person simultaneously and independently scored a randomly selected 33% of sessions for each participant. Each word was scored as either an agreement or a disagreement between observers based on whether observers obtained the same score (correct or incorrect) for that word. Interobserver agreement was calculated as the number of agreements divided by the total number of letters or words read. The mean interobserver agreement was 98.2% and never fell below 94.0% across all sessions assessed.

Design

John's skills and performance were assessed through a multiple baseline design in which phase changes were introduced across three sets of reading materials. In other words, John used all three sets of materials during each session. Rewards and/or instruction were introduced for each set of materials at different times. Please see Figure 1 for specific introduction times. A sequential introduction was used in order to determine whether the changes in performance that might follow their introduction were due to the reward, instruction, or combination. Introducing those procedures on all three sets of material at the same time would not allow determination of whether changes in performance that happened at the time of the change of phase were due to intervention or to another event that might have happened at the same time. Specific phases are described below.

Figure 1. **Dolch words read correctly, letter sounds produced correctly, and letters named correctly graphed by session and experimental phase for John. Mastery criteria of letters sounded and named correctly are 52 correct: 26 each lower and upper case. The filled square indicated on the letter names graph indicates number letter names correct during practice session.**



Baseline. During baseline sessions, all three tasks, letter names, letter sounds, and Dolch word reading, were assessed in that order, in the following manner. John was asked to read each letter name, sound, or word. He was asked to do his best reading. If John asked what one was, stopped for 3 s, or struggled with a word for 3 s, he was told the letter or word and it was marked as incorrect. During each session, John read one sheet each of letter names, letter sounds, and Dolch words for two minutes each. No reward or feedback was provided to John regarding his scores.

Reward. Reward sessions were conducted in the same manner as baseline sessions except as described below. For each task, John was told his score from the previous session. He was then told that if he exceeded his previous score, he would be allowed to select a coupon. Each coupon could be exchanged for a reward from one of the six categories of rewards available in the summer program. These rewards included one-to-one adult time, access to games, edibles, breaks from instruction, and decorated school supplies. John was told his letters or words correct after each sheet was read.

Reward and instruction. Reward and instruction sessions were conducted in the same manner as the reward session except as described below. The sheet of letter sounds, letter names, or Dolch words was read to John to a point 20% beyond his score from the previous session. John then read the list to the same point with any errors corrected for him. Following this instruction, a standard reward session was conducted.

Repeated instruction. This phase was similar to the instruction part of reward and instruction, except that instead of one instance of reading of the Dolch words, these words were read to him and he read them back until he read them correctly. Following this mastery instruction, John was asked to read the sheet as he did during the baseline session. This repeated instruction phase was implemented due to the fact that during the first set of instructional sessions, John did not pay adequate attention to his practice, choosing instead to rush through the words without spending the time necessary to make a good attempt at each word.

Treatment Integrity

An observer measured the treatment integrity (Sechrest, 1982) of 33% of the sessions by using a checklist to record the experimenter's implementation of the session procedures. The experimenter performed the procedures with 100% accuracy.

RESULTS

The results of John's skill and performance analysis are presented in Figure 1. Across all sets of materials, the introduction of rewards for improved scores produced increases in word and letter sound production. For words correct, the addition of instruction did not increase the scores John received on his word lists, so repeated instruction was used. During repeated instruction, John increased his score to a total of 18 words correct from a total of 5 during the first session of baseline.

For letter sounds, the introduction of instruction increased John's score over reward alone. Due to the end of the summer program, it was not possible to continue instruction of letter sounds.

For letter names correct, the graph indicates that John's scores decreased initially but steadily increased during reward plus instruction. During this phase, John practiced the letter names during instruction and named them all correctly. John was very resistant to "doing it again." The filled square at session 16 indicates that John did read all letter names correctly independently during the last practice session.

DISCUSSION

John's scores increased with the introduction of reward, indicating a performance deficit. However, it became clear that the use of reward would not increase those scores to mastery, a level of performance necessary for success in reading. Due to the fact that John's scores did not increase sufficiently with the introduction of reward, a skill deficit hypothesis also was indicated, and instruction was introduced to attempt to increase his scores. On Dolch word identification, a skill that would be necessary for John to read in first grade in the fall, John's mean score during baseline was 2, and during the repeated instruction phase, was 10.22. The analysis identified procedures that resulted in an increase in mean word identification rate of 511% between baseline and the final treatment phase. When using rereading of the same passages as instruction, a goal of a 40% increase in reading fluency (Carnine, Silbert, & Kameenui, 1990) has been recommended. Although not exactly the same as passage reading, it seems clear that John's increases when reading a variety of word lists could be described as an educationally significant change.

These procedures were completed in an almost ideal environment: one-to-one attention with a wide variety of rewards available for improved academic work. These factors allowed good opportunity to determine what skills John actually has. Based on the results during the reward only phases, he knows more than we might have originally thought based on baseline data. However, John still required instruction in addition to reward to continue to learn those sets of skills. These are facts for which we had no hard evidence prior to the assessment, and which will allow us to plan better interventions for John in the future.

Similar procedures could easily be adapted to any academic skill that is testable in short periods of time. For example, a student might be falling behind her class on regular math fact tests. Addition, subtraction, and multiplication facts might be used as the different tasks, and reward introduced to each in succession. If reward increases the rate of facts correct, it will be clear that the student has the skill, but does not perform to criterion without some type of reward. If the rate is not increased with reward, it will indicate a skill deficit, and suggest additional instruction. Reward then may be used to assure that new facts learned are maintained over time.

It is extremely important that when using such procedures, the strength of the reward used is adequate to motivate the student to do her best work. For example, stickers are used frequently in schools as rewards. However, for many students, a sticker is unimportant, and therefore is unlikely to change behavior. At the very least, an informal assessment of possible rewards is needed before trying to use them with students. This might be done using a list of rewards that are available in the student's educational environment and asking that student to rate each item's desirability. Alternatively, a discussion with the student and/or parents could also provide information regarding rewards that might motivate a student to perform. Regardless of the format, attention to rewards is a must in order to maximize the probability that these procedures will provide useful information.

Although additional work is needed to develop more specific procedures for different skill assessments, these procedures provide a promising method for isolating skill and performance deficits and for suggesting viable educational strategies.

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SIMULATING A SHAPING TASK

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A neural network simulation of Eckerman, Hienz, Stern, & Kowlowitz' (1980) "Long Key" experiment showed a good match to the effective shaping of the location of a pigeon's keypeck. The neural network model was biologically based on In-Vitro Reinforcement (IVR) principles of learning. The behavioral function of the model was a "Win-Stay" strategy. Results indicated that control by consequences can account for a substantial proportion of the shaping reported in the original experiment. The simulation and its analysis are good examples of new techniques for neural network simulation, including semi-situational simulations and direct analysis.

Shaping is one of the most widely used techniques in applied behavior analysis. Despite this, very little experimental analysis of shaping has been reported from the laboratory. The present study continues the authors' efforts to use neural network simulations as a tool for the analysis of shaping. Specifically, we will show how a network based on the principles of In-Vitro Reinforcement (IVR — Stein, 1997; Stein, Xue, & Belluzzi, 1993; 1994; Stein & Belluzzi, 1989) accounts for experimental results of pigeons' key pecks shaped using a Long Key apparatus (Eckerman, Hienz, Stern, & Kowlowitz, 1980).

Across psychology, the use of computer simulations is becoming more and more common. Most of these simulations are not behavioral. And most of the methods and techniques developed to analyze these simulations are not appropriate to a behavioral analysis. Even in the case of behavioral simulations, it is not always the case that the phenomena simulated are of especial interest to the clinician. The present study uses a novel technique called *direct analysis* (Kemp & Eckerman, 2001), which allows the prediction of behavior from almost any experimental analysis. By selecting an experimental analysis of shaping, we hope that the present report illustrates how simulating a neural network on a computer can lead to analyses of behavior of value to the clinician.

Direct analysis means subscribing to the desiderata proposed by Church (1997). One way of speaking about direct analysis is to say it involves attempting to simulate an experiment, rather than an experimental effect. This means that the computer software that performs the simulation is composed of at least three separate programs (called *modules*), one modeling the experimental procedure and apparatus, another modeling the organism's sensorimotor systems, and the third modeling the behavior. The outputs of one module are input into the next, in a cycle. Kemp & Eckerman (2001) refer to this sort of simulation as *situational*. The third component module is the neural network model. The remainder of the software constitutes what Kemp & Eckerman call the In Situ testbed, used to evaluate the performance of the model with respect to the performance of the original organisms in the same experimental procedure.

Because the output of the behavioral module impacts the sensorimotor module, the level of detail at which the behavior is modeled must be very fine-grained -- both temporally and spatially. Not only each session, but each trial and each response, and often unmeasured responses (such as crossover responses and observing responses, etc.) as well, must be simulated individually. This is what we mean by simulating an experiment, rather than just an experimental effect.

Direct analysis is distinct from other types of quantitative analysis of behavior. Typical computer simulations merely calculate the functional relations. The inputs to traditional simulations are parameters describing the contingencies and the outputs are parameters characterizing the behavior. As such, they are abstractions away from the moment-to-moment details of an organism interacting with its environment (Skinner, 1976). In contrast, the output from a situational simulation system is a record of behavior with the same structure as the data recorded from the original experiment. Instead of calculating the functional relations as part of the simulation proper, a situational simulation generates predictions of the behavior on a moment-to-moment basis. Then the same equipment and/or statistical software used to analyze the original experimental data can be used *directly* to analyze the simulation data.

Just as the original analysis (whether by graphing or with statistics) reveals the functional relations in the experimental data, the corresponding analysis of the simulation predictions reveals the functional relations within the simulation data. Another way of saying this is that, in direct analysis, functional relations are not simulated. Instead, functional relations are discovered within the simulation. If the simulation data fail to show the same functional relations as the real behavior, that constitutes evidence disconfirming the behavioral model underlying the simulation.

In the present study, the behavioral model evaluated within the simulation is a *neural network*. Neural networks are a particular type of *biobehavioral* model (Donahoe & Palmer, 1994). In biobehavioral models, the computational model of the behavior is constrained by two types of experimental evidence, behavioral and biological. The simulation provides an inferential link between hypothetical sequences of real, experimentally validated brain events and the resultant behavior. The direct analysis compares the predicted behavior with the behavior reported in the original experimental analysis. This is the advantage that simulating neural networks on a computer provides. It allows the behavior analyst to incorporate data from the recent explosion of brain research into the analysis of behavior.

The particular sort of neural network used in the present study is a new variation on *activationist* neural networks (Kemp, 1997; Kemp & Eckerman, 2000). The basic design of activationist neural networks is that the fundamental relation modeled is that between behavior and its consequences, rather than between behavior and its antecedents. In standard *connectionist* neural networks, learning is modeled by altering the efficiency of connections between models of sensory systems and models of motor systems. In activationist neural networks, learning is modeled by altering the likelihood of emitting different types of behavior, dependent upon which behaviors have been reinforced. Discriminative control is intrinsic to connectionist networks. It is secondary in activationist networks.

The original experiment being simulated here is often referred to as the Long Key experiment (Eckerman, Hienz, Stern, & Kowlowitz, 1980). The authors shaped the location of pigeons' keypecks within a 10 in. wide strip. Pecks falling within a specific inch were reinforced. The location of this reinforced area shifted from one end of the strip to the other (a "sweep") and then back. Distance separating the current reinforced area from the next was varied (step sizes from 0.5 to 3.0 in) as was the length of training at a specific location (step rate 25 to 400 reinforcers). All conditions produced effective shaping, with larger step sizes producing somewhat faster shifts in location.

In broad terms, the theoretical account of the successful shaping of the location of the pigeon's peck is as follows: Three response classes are of interest; pecking; reorienting the head to the right (right shift), and reorienting the head to the left (left shift). All other responses are classed together solely in terms of the time they might take away from these three types of responses. Since only pecks on a key that is currently programmed to produce reinforcement are reinforced, the peck response will most often be the most recent of the three types emitted when a reinforcer is delivered. This will tend to increase the likelihood of pecking as compared to shifts after reinforcement due to pecking a key programmed to produce reinforcement. Pecks on a key that is not programmed to reinforce pecking will result in a decrease in the likelihood of pecking relative to both sorts of shifts.

Therefore, after reinforcement, the pigeon will tend to stay where it is and after non-reinforcement, it will tend to shift to another key. This can be thought of as a win-stay strategy (Harlow, 1949).

To implement this win-stay strategy, we will use a variant of the Clavier model (Kemp & Eckerman, 2000) with three emitter units, one for each response class. We call this new model, Calliope. It differs from the previous activationist networks in that it relies upon asynchronous updating (Sutton & Barto, 1998) to decide amongst competing responses. We will see how this technique causes the model of the organism to maintain responding on the reinforced keys and then to shift when reinforcement shifts. The net result was a solid qualitative match to the performance of the pigeons in the original experiment.

METHOD

The simulation technique used in the present study, *situational simulation* (Kemp & Eckerman, 1995; Church, 1997; Kemp & Eckerman, 2001), consists of separate simulation modules (a) for the experimental procedure, (b) the organism's sensorimotor system, and (c) the artificial neural network model to be evaluated. Inputs from one module are passed as outputs to the next. When the signal completes its cycle through all of the modules, the next cycle begins. Each cycle corresponds to a finite unit of time. The simulation consists of the iteration of many cycles until the entire experiment is simulated. Data generated during the simulation is output into a separate file in a format matching the data file from the original experiment. Multiple runs of the simulation with different *pseudo-random seeds* (see Results section below) were used to model different subjects.

Model

The neural network model used in the current simulation is called Calliope. Like previous activationist models (Kemp & Eckerman, 2000), the central component of the model is a set of emitter units, the output of which produce the simulated motor movements that are interpreted as responses by the testbed. The key difference between Calliope and the previous models is that presynaptic signals to the emitter units accumulate gradually over time until they exceed the emitter unit threshold, which produces the output.

The present implementation of Calliope, intended to come under control of the Long Key contingencies, has only one set of three emitter units. Each emitter unit corresponds to one motor movement. The three motor movements, shift LEFT, shift RIGHT, and PECK, that constitute the output of the model are described below (cf. Procedure section). These are the outputs of the model. Neurophysiologically, they correspond to the Ca++ modulated "bursts" identified by Stein, Xue, & Belluzzi (1993) as coming under control of In-Vitro Reinforcement (IVR).

There are two types of inputs to the neural network model, corresponding to discriminative and reinforcing stimuli, respectively. Following a suggestion by Larry Stein (personal communication), discriminative inputs correspond to Na^+ modulated spikes, presynaptic to the emitter units, while reinforcing inputs correspond to the diffuse dopamine controlling the rate of IVR bursting by the emitter units. The discriminative signal is a small random number randomly assigned as input to one of the emitter units on each iteration cycle. The reinforcement signal (Sutton & Barto, 1998) is either one or zero, available to all emitter units on each cycle.

Emitter units. At a biophysical level, emitter units are intended to model the pyramidal cells discovered by Stein, Xue, & Belluzzi (1993) to be subject to In-Vitro Reinforcement (IVR). IVR is a procedure where the rates of Ca^{++} modulated "bursts" (rapid sequences of three to five axonal spikes) output by pyramidal cells (found in the CA1 area of the hippocampus) are controlled by injection of diffuse dopamine contingent upon prior bursting. If dopamine follows closely after a burst, the subsequent rate of bursting increases. In the absence of dopamine, or with non-contingent dopamine, the burst rate decreases (Stein, 1997; Stein, Xue, & Belluzzi, 1993; 1994). A basic assumption of Calliope is that a burst from one emitter unit generates one and only one type of motor movement.

Mathematically, an emitter unit consists of an activation level (ranging over the non-negative real numbers), a threshold (ranging from zero to one, non-inclusive), and a binary output signal indicating the presence of a burst (zero for no burst, one for a burst). On each iteration cycle, one of the three emitter units in the emitter set is selected at random and the activation level is increased by a small amount, the discriminative signal. (This signal models the increased potential of the pyramidal neuron due to pre-synaptic Na^+ spiking activity. The amount is distributed as an Erlang pseudo-random variate with scale parameter of .0714 and shape parameter of 2, plus a constant intercept value of .05 (Evans, Hastings, & Peacock, 1993, p.56). The specific choice of the Erlang distribution was made somewhat arbitrarily. The effect was to successfully vary the order in which the emitter units burst, while holding the relative burst rates constant.) If the activation level fails to exceed the threshold, that is the end of the cycle. The burst output is zero.

If the activation level exceeds the threshold, that is the condition for a burst output. The output is set to one. The threshold is raised by a small amount. (This models the tendency for burst rates to slow over time in the absence of reinforcement.) Finally, the activation levels (for all neurons in the set) are reset to zero.

On any cycle when the reinforcement signal is one, all thresholds are lowered proportionately to the amount of time since each corresponding emitter unit last emitted a burst. (This models the increase in burst rate due to reinforcement, which exhibits a steep delay-of-reinforcement effect of known characteristics; Stein & Belluzzi, 1989.)

Interconnections. Two sorts of interconnections between emitter units are used in the model. The first type determines the likelihood that each of the emitter units will receive the discriminative signal. For the simulations reported, two distributions over the emitter units were used, corresponding to the two possible discriminative stimuli. For a lit key (S^D), all three emitter units are equally likely to receive the discriminative signal on any trial. For a dark key (S^Δ), the emitter units corresponding to shifts (LEFT or RIGHT) are five times more likely to receive the discriminative signal than is the PECK unit.

The second sort of interconnection between units relates to axo-axonal inhibitory signals generated by a burst. After a burst, the activation levels for all three emitter units are reset to zero. While the specific neuroanatomy for these interconnections is not provided in Calliope, the more precise structure of a prior model, Vibraphone (Kemp & Eckerman, 2000), provides some suggestion as to how these interconnections might be organized. Mathematically, the net effect is to increase the autocorrelation of emission by the unit with the lowest threshold. Functionally, this increases the control over specific responding by reinforcement.

Performance rule. Critical to using direct analysis to evaluate a model is what Daly & Daly (1982) call the model's *performance rule*. Many traditional models only output values for response strength. Even in models more suited to moment-to-moment simulation, there are often numerous possible ways to determine exactly which response is generated at any given moment. The performance rule is the specific algorithm that determines which response (or motor output, depending upon the interpretation of the model) is output at every iteration cycle of the simulation, based upon the current state of the model. (In traditional models, if a performance rule is included, that rule is a function of the response strengths and specifies the choice of a single response at each moment.)

In Calliope, the performance rule is simplified by the use of random asynchronous updating (Sutton & Barto, 1998). On each iteration cycle, one emitter unit is selected randomly based on relative likelihoods determined by the discriminative stimulus. The activation level for that and only that emitter unit is increased due to the current presynaptic Na^+ spiking. Because, on any given iteration cycle, the activation level of only one emitter unit is incremented, only the threshold for that emitter unit can be exceeded on that iteration cycle. If that threshold is exceeded, then the motor movement corresponding to that emitter unit is output. This insures that at most one of the three motor movements is output at any given time. There is never any ambiguity as to which motor movement occurs at any moment.

Learning rule. The learning rule for Calliope is based on that used in prior models, including Clavier (Kemp & Eckerman, 2000). The lower the threshold, the higher the probability of a burst, and vice versa. On any iteration cycle where a reinforcement signal is present, the threshold is lowered proportionately to its current value and also proportionately to the time since that unit last emitted a burst. On any cycle where a unit bursts, that unit has its threshold raised towards a value of 1.0 proportionately to the difference between the current value and 1.0. As with prior models, the ratio of the basic increments of raising and lowering the threshold is set based on the value of 30% determined to be optimal for percentile reinforcement in shaping procedures (Galbicka, 1998).

Apparatus

Hardware. All simulations and analyses were performed on a DELL® Dimension XPS T550 running the Windows NT Workstation 4.0 operating system.

Software. Simulations were programmed in SNOBOL4+™ (Catspaw, Inc., 1985), version 2.12, within the Virtual DOS Machine (VDM) of Windows NT. Analyses were programmed in SAS/Graph® (SAS Institute, 1996), version 7.0.

Design.

A goal of the simulation was to match, as closely as possible, the original experimental design (Eckerman, Hienz, Stern, & Kowlowitz, 1980). In the original experiment, key pecking by pigeons was reinforced by brief access to grain when the pecks were within a specific inch (reinforced area) of a ten inch wide illuminated area, called here the *Long Key*. This area was located on one wall of the experimental space, at a height of 22.6 cm and above a centrally located opening for the grain feeder. The area was composed of 20 .5-in. wide clear Plexiglas keys. During the experiment, the two adjacent keys constituting the reinforced area shifted to the left or to the right across the Long Key. For the portion of the experiment simulated here, each shift constituted a session. A series of shifts across the entire Long Key is called a *sweep*.

Testbed design. The overall structure of the testbed conforms to the In Situ design (Kemp & Eckerman, 2001), consisting of a virtual reality (VR) component to model the environmental contingencies, an artificial life (AL) component to model the sensorimotor capacities of the organism, and an artificial intelligence (AI) component to model the behavioral functions. The AI component corresponds to the neural network model being tested.

Communication between components is extremely restricted (Church, 1997). Signals travel in a cycle from the VR component to the sensory portion of the AL component to the AI component to the motor portion of the AL component and back to the VR component. Output from the VR component, input to the sensory-AL component, models only those aspects of the environment capable of affecting the organism's sensory systems. Output from the sensory-AL component, input to the AI component, models only the changes to the organism's sensory systems plausibly generating neural signals within the central nervous system (CNS). These signals serve as input to the model being evaluated, which constitutes the AI component. Output from the AI component, input to the motor-AL component, models only those neural signals from the CNS plausibly capable of affecting the organism's motor systems. Output from the motor-AL component, input to the VR component, models only those changes in the organism's motor systems capable of altering the organism's posture, orientation, or location (POL) with respect to the environment. When these changes in POL also alter the state of the environment in some measurable way (e.g., depressing a key with sufficient force to close the key switch), we refer to the signal as a *praxis*. When the POL changes do not alter the state of the environment, we refer to the signal as a *taxis*.

VR component. The VR component of the In Situ testbed must model both the mechanical apparatus surrounding the pigeon and the schedule of contingencies. A data structure modeling the 20 keys includes information as to whether each key is lit or unlit, whether the key switch is closed or open, and what schedule -- extinction (ext) or continuous reinforcement (crf) -- is programmed for that key at that time. A variable for storing the response count for each key is also included. A second data structure contains codes for the appropriate reinforcement schedules for each key for each session. Variables separate from both data structures indicated how and when discriminative stimuli and reinforcement criteria would occur.

AL component. The AL component must model both the sensory and motor capacities of the organism needed to simulate the original experiment. The vast majority of details of what it takes to be a pigeon are not included in the AL model. The AL model, called here a *cyber-pigeon*, consists of three elements: (1) a data structure containing cutoff values that determine the probability that each emitter unit is activated, depending on the discriminative stimulus, (2) a data structure that ties each emitter unit to its corresponding bodily movement, (3) separate variables that store the values for the current location of the cyber-pigeon relative to the Long Key and the current motor movement.

AI component. The AI component of the simulation system is the artificial neural network model being evaluated. The AI component must determine when behavior occurs on a moment to moment basis. In order for the results of the simulation to match those of the original experiment, the neural network model must cause the AL component to come under control of the environmental contingencies in a manner analogous to how the subjects of the original experiment came under control of the original contingencies. The details of neural network are given above in the Model section.

Data recording. A separate module, the data management (DM) module, stores the data during the simulation. At the end of the simulation, the DM module records the data in print form. During the simulation, response counts, broken out separately by sweep by session by quarter-session by key, are stored for later graphing. At the end of the simulation, two reports are generated: (1) a response report containing the data for graphing and (2) a final summary report containing summary statistics for the entire simulation for that cyber-pigeon under that condition.

Procedure.

The simulation was also designed to match the original experimental procedure step by step and moment to moment. Only some of the original experimental conditions were simulated in the present study.

Original experimental conditions. At first, the reinforced area was the rightmost inch. This reinforced area was then shifted repeatedly to the left, with the shifts being either 0.5, 1.0, 1.5, or 3.0 in. Shifts were made after each 25, 50, 100, 200, or 400 reinforced pecks (rf). When the leftmost inch was reached (one "sweep"), the direction of change was reversed and the reinforced area was shifted to the right until the rightmost inch was reached (a second "sweep"). These "sweeps" continued for a minimum of six sweeps of the key.

Step size (0.5 - 3.0 in) was manipulated as either a between-subject or a within-subject variable. For other pigeons, step rate was manipulated, with shifts being made after either 25, 50, 100, 200, or 400 rf. These step rate conditions were compared using a between-subject design with a step size of 0.5 in. Using a within-subject design, however, some pigeons were trained with step-size/step-rate combinations that maintained a constant ratio (0.5 in/50 rf, 1.0 in/100 rf, or 3.0 in/300 rf).

Simulation conditions. In the simulation, each iteration cycle corresponds to one tenth (1/10) sec. of real time. Initial pilot testing of the simulation system was done with shift of 0.5 in. (one key), made after 100 rf. After pilot testing, for each simulated subject (called a "cyber-pigeon, see Results section below), shifts were 1.0, 1.5, and 3.0 in., made after 100 reinforcers. The procedure consisted of a series of stages.

Initial shaping. In the original experiment, pigeons were magazine trained and then trained to peck the two rightmost keys of the Long Key, which were both lit and scheduled for crf. The other keys were dark. This session was simulated for the cyber-pigeons, except that no prior magazine training was required. At the start of the initial shaping session in the simulation, the cyber-pigeon was placed in front of the center of the Long Key, which was dark.

Stabilizing responding. The next stage in the original experiment was to fade the dark-light contrast over the Long Key, raising the level of illumination until the entire Long Key was evenly lit. This step was not simulated. In the simulation, training proceeded directly from initial shaping to shaping key location with full illumination of the key.

Shaping key location. The next stage in the original experiment was to stop reinforcement on the two rightmost keys and begin reinforcement on two other keys, displaced from the original reinforced location by either one, two, three, or six keys (.5, 1.0, 1.5, or 3.0 inches, respectively). A given pair of keys was reinforced until 25, 50, 100, 200, 300, or 400 reinforcers had been obtained. Not all combinations of step size (number of keys across which reinforcement was displaced) and step rate (number of reinforcers obtained on each pair of keys) were used for all pigeons. This stage was also simulated, but only for some conditions (specified below).

Varying step size. The series of conditions used in the original experiment to perform within-subject analyses (Eckerman, Hienz, Stern, & Kowlowitz, 1980, Figs. 2 and 3) was to vary the size of the shift after 100 reinforcers through 1.0, 1.5, and 3.0 inches. It was this sequence of conditions that were simulated for 22 cyberpigeons.

RESULTS

Direct Analysis

The technique used to compare the results of the simulation is somewhat novel and is described here.

Simulation inputs. Inputs to the simulation must match, as closely as possible, the values of the independent variables of the original experimental analysis being simulated. Most important of these, of course, is the reinforcement schedule, which is part of the VR component of the simulation. Beyond this, an important distinction must be made. Computer systems are importantly unlike the real world in which experiments are conducted in that, in principle, everything going on in a computer can be controlled absolutely. In an experiment, environmental variables are controlled insofar as is possible, and organismic variation is controlled indirectly thereby, leaving an inevitable surplus of uncontrolled individual and intraindividual variation.

These uncontrolled variations are simulated on the computer using a pseudo-random number generator. A pseudo-random number generator is a computer algorithm that produces a fixed sequence of numbers where each number is unpredictable from the preceding numbers in the sequence. Different sequences are produced by different random seeds. Seeds are the numbers used to start the generator sequences. For our present purposes, it is easiest to think of each simulation run with a different seed as being equivalent to a procedure run with a different individual organism. Each "cyber-pigeon" in our experiment is designated by the number corresponding to the random seed used.

Simulation outputs. The final outputs of the simulation are compared to the outputs of the original experimental analysis. Because a situated simulation allows the researcher to extract functional relations rather than merely to simulate them, the outputs of the simulation software should be compared to all of the measured outputs of the experimental analysis. In a situated simulation, the simulation outputs are recorded at the same level of detail at which the original outputs were measured (e.g., the time of each individual response, what Church, 1997, calls a Time.Event format). This allows any summary measures calculated from the original experimental data to be calculated from the simulation data as well. Most commonly, in non-situated simulations, the simulation output is generated at a less detailed level than the original outputs were measured (e.g., responses per minute) and thus can only be compared to the corresponding summaries of the experimental data.

In computer science terms, we can speak in terms of comparing the data set output from the experiment with the data set output from the simulation. Each data set has a structure (number and type of variables, levels of measurement, etc.) and content (the values of the variables). A crucial component of a situational simulation is to match the structure of the two data sets as exactly as possible

(Church, 1997). This radically simplifies the problem of comparing the content of the two data sets. In the present study, where the original experimental analysis was graphical, the output of the simulation will be graphed in the same way the output of the experiments were, allowing the two sets of graphs to be compared directly. Kemp & Eckerman (2001) call this a direct analysis.

Task Completion

For all four step sizes (.5, 1.0, 1.5, or 3.0 inches), 22 cyberpigeons were run through initial shaping, followed by two full sweeps, first to the left and then to the right, concluding with reinforcement of pecking on the rightmost two keys.

In the original experiment, each session terminated when either 100 reinforced keypecks occurred or 30 minutes elapsed. Only four of the 18 pigeons failed to satisfy the reinforcement requirement within the first 30 minutes of initial shaping. Sessions of initial shaping were repeated until each pigeon had satisfied the requirement. No data are reported on failures of real pigeons to complete any other sessions after initial shaping for any condition. In contrast, whenever a cyberpigeon failed to satisfy a reinforcement requirement for any session, the simulation terminated. Approximately one simulation in 10 had to be terminated prematurely. In the simulation, for runs under any condition, one cyberpigeon would fail to complete one session approximately once every 500 sessions (across multiple pigeons). Data from any cyberpigeon who failed to complete any session was dropped from the study and not analyzed further.

Shaping

A total of eight cyberpigeons completed all three of the larger step sizes (1.0, 1.5, or 3.0 inches) and were graphed. Data for two of these, cyberpigeons 538 and 588, are displayed in Figures 1 and 2. These two graphs compare favorably to Figures 2 and 3 of Eckerman, Hienz, Stern, & Kowlowitz (1980) for two real pigeons, numbers 433 and 434.

Because the simulations for each step size were reset, each cyberpigeon, unlike the real pigeons, was essentially naïve at the beginning of each set of sweeps for each new condition. This accounts for the fact that the first line graphs at the upper-right portion of each condition are identical within each graph.

Comparison to experimental results.

Two sorts of comparisons to the experimental results were made. Graphs of the first two sweeps for the three step sizes for several cyberpigeons were generated to match, as closely as possible, the format of the Figures in the original experimental report. The graphs were compared. Also, ratios of reinforcers to responses were calculated for several conditions and were matched to the same ratios reported for the original experiment. Figure 3 of the present report was compared to Figure 5 of the original experimental report. In all cases, a good qualitative fit was found.

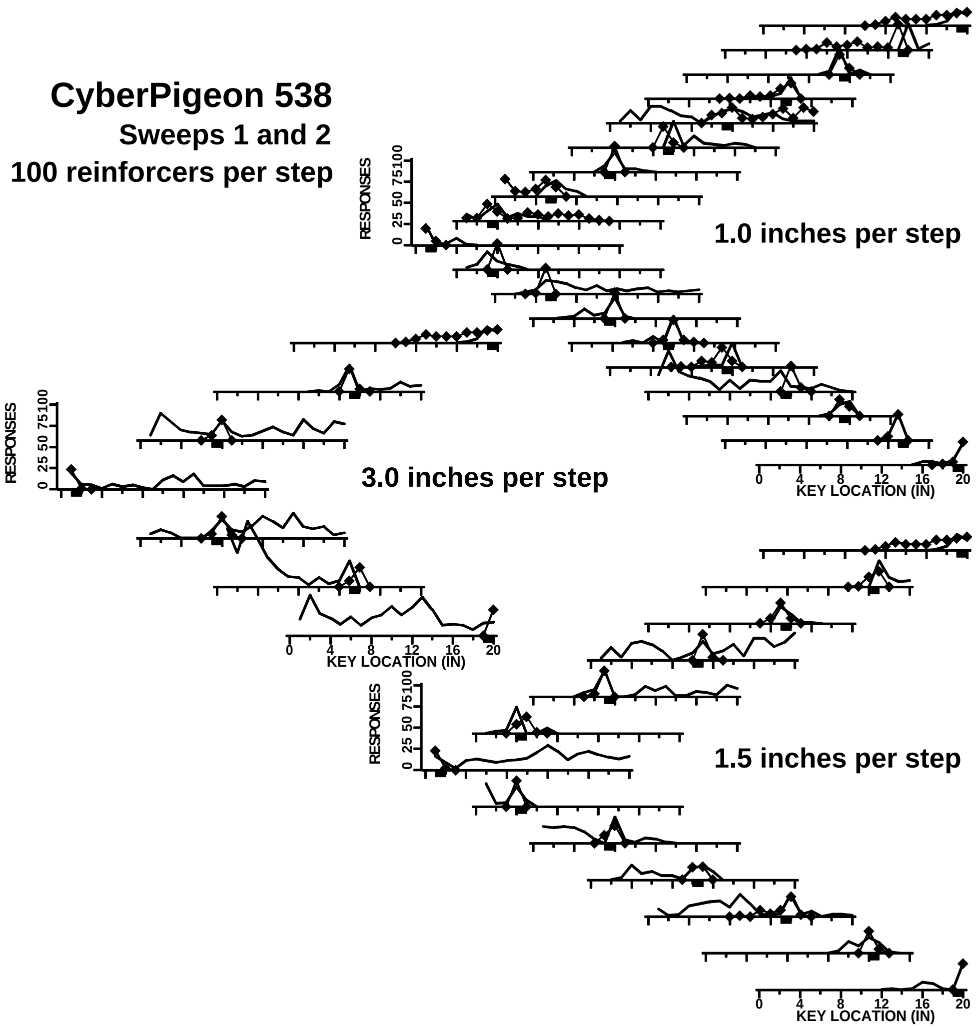
Parameter sensitivity. Computational models always contain parameters, variables which must be set to some specific value in order for the simulation to run at all. Some parameters model known features of the behavior, such as the delay of reinforcement gradient. Others are intervening variables, which may or may not correspond to some feature of the nervous system, but which correspond to no measurable feature of behavior or environment. These are called “free parameters.”

When simulation results do not vary substantially when a free parameter value is varied, the parameter is said to be insensitive. Because insensitive parameters do not affect simulation results, once a parameter is determined to be insensitive, it can be neglected with regard to the fit of the model to the data. Three parameters (described immediately below) in the present simulations were determined to be sensitive. These three parameters can be considered to be essential to the model’s fit. Changing any of the three drastically altered the number of cyberpigeons that completed two full sweeps with a step size of .5 in.

The three sensitive parameters were: discrimination intercept value; activation reset correlation; and threshold change rate. With the best parameter values, 20 out of 22 cyberpigeons completed two full sweeps. When the intercept value for the random variable determining the discriminative signal is lowered from .05 to zero, only 9 of the 22 cyberpigeons completed. When only the emitter unit that burst has its activation level reset (as opposed to resetting all emitter units in the actual model), only 4 of the 22 cyberpigeons completed. When learning was turned off (thresholds were not altered), none of the 22 cyberpigeons completed.

Experimental results. In the original experiment, by the final 25 rf given at a particular reinforced area, between 30-40% of pecks were

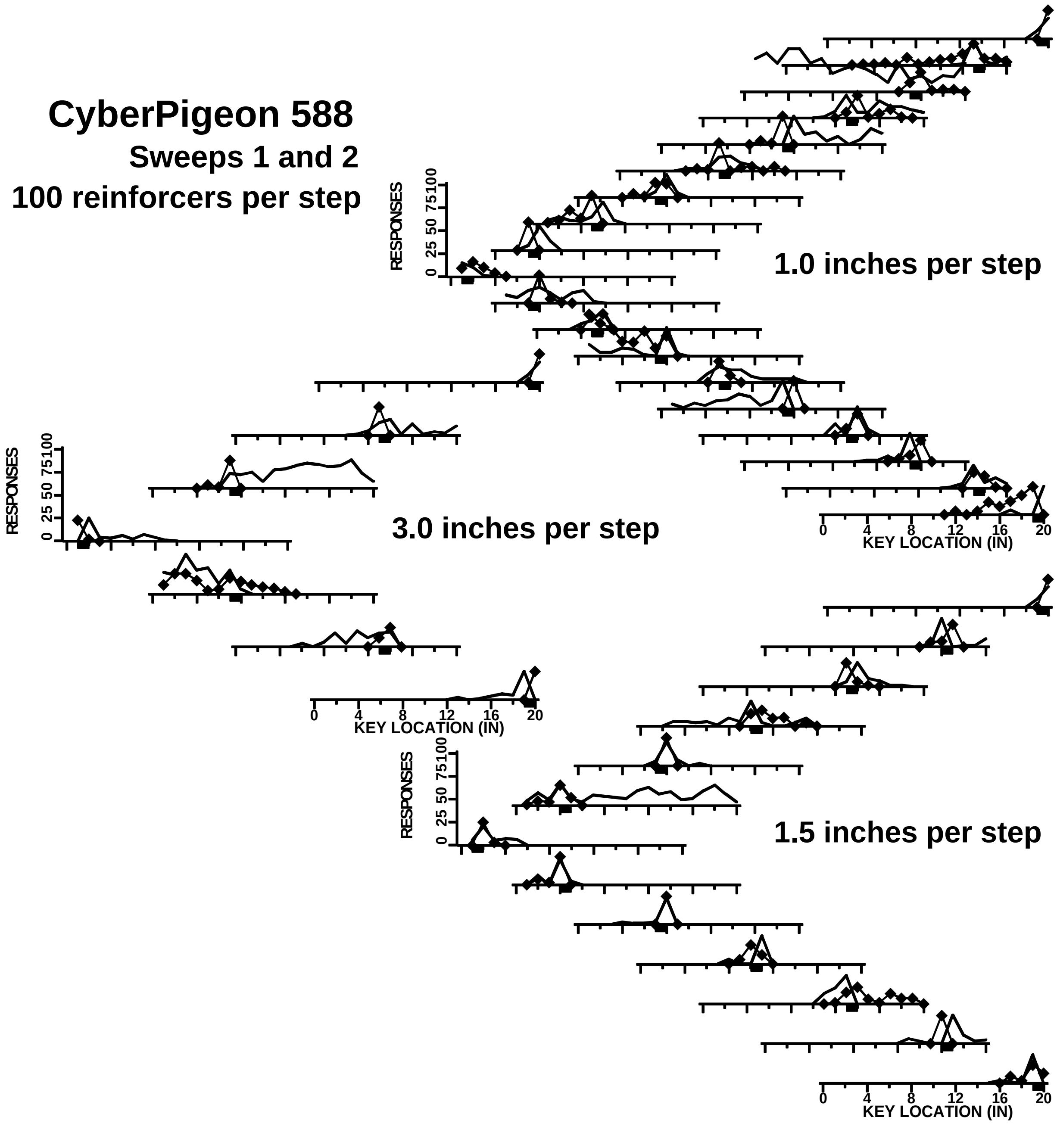
<u>Figure 1.</u> For Cyberpigeon 538, frequency of pecking each key location in the first and second sweeps under three different shaping step sizes. The first presented condition is at the upper right. The reinforced key locations are shown as a dark bar along and immediately beneath the abscissa. The distribution for pecks emitted prior to the 25th reinforcer at a location are shown as a frequency polygon without diamonds. The distribution for pecks emitted during the last 25 reinforcers at a location are shown as a frequency polygon with data points indicated as diamonds.



reinforced. Thus, within the ranges explored, neither step-size nor step-rate affected this final performance. Larger step sizes did, however, require the bird to make a measurably greater shift in peck location. For 0.5 in shifts, for example, about 20% of the pecks fell in the "next" reinforced area prior to a shift. For larger step sizes, this percentage declined to 10% (1.5 in) or 2% (3.0 in). Given this greater "selective pressure," one can ask whether shaping occurred more strongly with smaller or larger step sizes. Since for all conditions approximately 20-25% of pecks were reinforced during the first 25 rf at a particular location, a greater shift in response location was achieved for larger step sizes. Thus larger step sizes produced more efficient shaping (fewer rf per distance change). No influence on shaping effectiveness was seen for step rates within the conditions evaluated.

<u>Ratios for simulated data</u>. Figure 3 shows the degree of control over location of four individual cyberpigeons' keypecks, across three step sizes (1.0, 1.5, and 3.0 inches). By the final 25 rf, over 70% of responses were reinforced. This kept the number of pecks falling in the "next" reinforced area below 10% for all conditions for all cyberpigeons. Even during the first 25 rf, over 30% of responses were reinforced for all but one case (step size 3.0 for cyberpigeon 538). Control was clearly more effective for cyberpigeons than for real pigeons. The only other

<u>Figure 2.</u> For Cyberpigeon 588, frequency of pecking each key location in the first and second sweeps under three different shaping step step sizes arranged for each of these four cyberpigeons. The proportion is shown (a) for the last 25 reinforcers at the steps (Final), (b) for the first 25 reinforcers at the steps (Initial), and (c) for the next-to-be-reinforced keys during the last 25 reinforcers of the steps. Each data point represents the data for exposures to these shaping steps following the initial shaping condition. Data were included for all shaping steps each sweep.

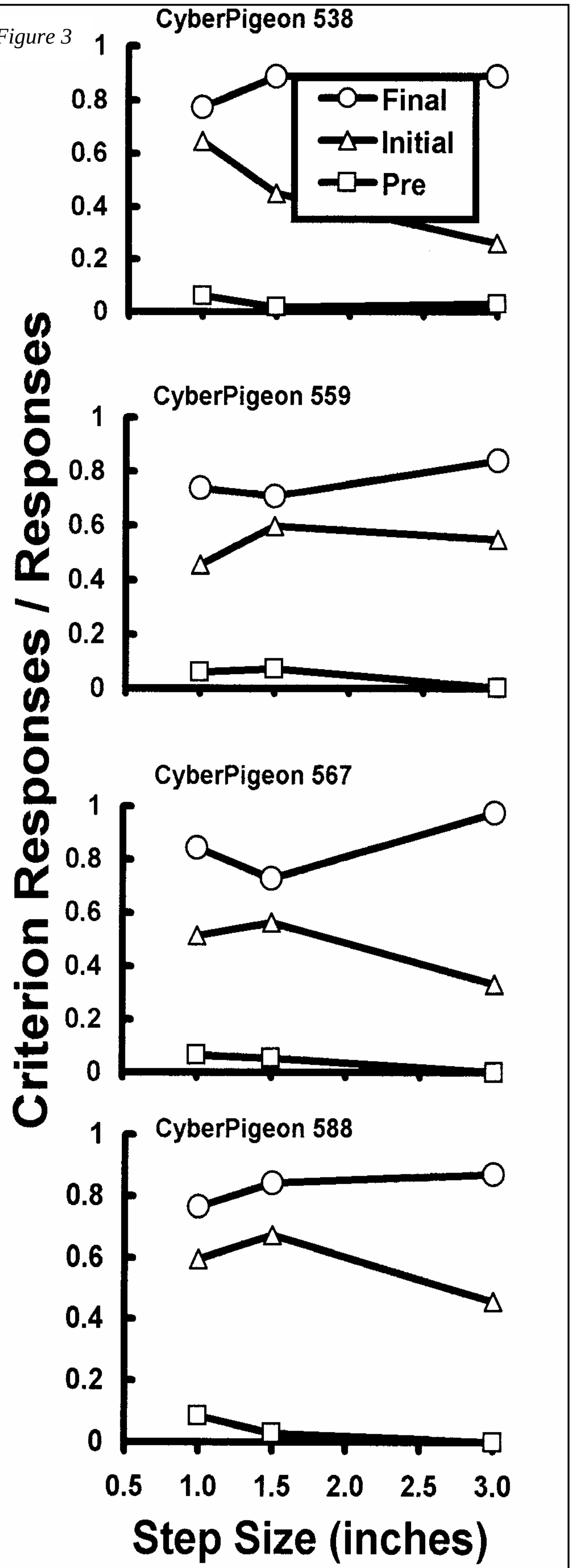


noticeable difference was a tendency for early acquisition to be moderately slower for the 3.0 step size than for the other step sizes.

DISCUSSION

The main result of both the experiment and the simulation is that keypecking successfully tracked

Figure 3



the scheduled changes in reinforcement across key positions. A simple Win-Stay model, constrained by neurophysiological data, provided a reliable match to the data at the level of detail reported in the publication.

Semi-situated simulations.

We refer to the present simulation as "semi-situational," a term that deserves some clarification. A "fully situated" model is an ideal (Kemp & Eckerman, 2001; Kemp, in press). In practice, we say that a model is "situated" within the testbed if the environment and organism are modeled in sufficient detail such that organismic inputs and outputs can be unambiguously identified with their environmental causes and effects. We term the present model "semi-situated" because sufficient detail is provided for discriminative stimuli and for target responses and orienting responses, but not for reinforcing stimuli or for consummatory (feeding) responses. Reinforcing stimuli and consummatory responses could not be properly situated because the VR component did not include a model of the feeder.

Because reinforcement is not modeled situatively, the model of reinforcement deserves special note. Kemp & Eckerman (2001) distinguish between reinforcer presentation (e.g., the feeder opening) and reinforcer delivery (e.g., feeding). Reinforcer presentation is an environmental event. In the laboratory, reinforcer presentation is also a scheduled event. Reinforcer delivery ordinarily requires action on the part of the organism. A computational model of learning, such as a neural network, ordinarily includes a specific variable to model reinforcement (Sutton & Barto, 1998). Part of designing the simulation involves deciding exactly which events determine the value of the reinforcement variable at any given time. In the case of a fully-situated simulation, the value of the reinforcement variable is set to some positive value (called the reinforcement signal) at the time of reinforcer delivery. In a simulation like the present one, where there is no explicit model of reinforcer delivery, setting the value of the reinforcement signal is more complicated.

There is a great deal of experimental evidence that stimuli concomitant with reinforcer presentation, such as the sound of the feeder opening, acquire reinforcing properties as conditioned reinforcers (Skinner, 1938, p.70). The model of the environment in the present semi-situated simulation does not include a feeder. Therefore, there is no model of reinforcement delivery. During the simulation, the reinforcement signal is set immediately at the time when scheduled reinforcement delivery occurs.

Computationally, this is the simplest solution. Conceptually, however, it demands a leap over one of Skinner's (1984, p. 722; 1988, p.470) "gaps," specifically, "the temporal gap between the actions performed upon an organism and the often deferred changes in its behavior." In the present case, adverting to the possibility that stimuli concomitant with the opening of the feeder act as reinforcing stimuli appears to be the simplest way of leaping that gap.

When reinforcement is scheduled, the feeder opens. The sound of the feeder opening follows immediately. For purposes of the present semi-situated simulation, we assume that that sound, or some other concomitant stimulus, has already acquired reinforcing properties due to prior pairings with feeding opportunities in the chamber. This conditioned reinforcement is provided very rapidly without the necessity of movement on the part of the pigeon (unlike actual feeding, which requires the pigeon to peck at the food after the feeder opens). As such, it satisfies the computational requirements for the present simulation

Model Fit

The sensitivity of the intercept parameter for the discriminative signal is probably a technical difficulty having to do with limitations of computational models. The requirement that all emitter units be reset after each burst is problematic, because it requires specific interconnections to synchronize the resetting (Kemp & Eckerman, 2000). The neuroanatomical data to support the assumption of such neural structures is very limited (Crick & Asanuma, 1986). The sensitivity of the learning rule is actually a positive indication of fit. Had turning off learning not eliminated the match to the data, it could be argued that it was not reinforcement that caused the model to satisfy the schedule requirements and track the reinforcement across the Long Key. In short, the sensitivity of the simulation results to the variability of the thresholds support the hypothesis that it was reinforcement and not some artifact or other factor that shaped the location of the pigeon's peck.

Lessons Learned

An advantage to direct analysis in comparing neural networks to experimental data is that the reliance of the matches of different aspects of the data upon different parameters of the model can lead to various conclusions both about the model and about the behavior. The present analyses support the following interpretations.

Discriminative versus consequential control. An important feature of all the activationist models constructed thus far is the minimalist model of sensory systems. Calliope is the first such model to be subject to any kind of discriminative control. Even so, the model can only discriminate between an unlit and a lit key. Unlit keys are only present during initial shaping. The real pigeons subject to the original experiment were presumably capable of discriminating various stimuli useful in controlling their behavior. For instance, they would be able to discriminate their location in the chamber relative to either end of the Long Key, something the neural network cannot do. The fact that the cyberpigeons succeeded in an analogy to the same task as the pigeons while lacking the pigeon's discriminative capacities suggests that the behavior of the pigeons in the original experiment need not have and may not have come under discriminative control of these other environmental features.

This illustrates an important advantage of computer simulation over other types of behavior analysis. With real pigeons, organismic factors can only be varied crudely, by surgical lesions, drug administration, etc. With the cyberpigeon, we were able to turn off the parameter controlling reinforcement learning without altering the rest of the model. In computer simulations, both organismic and environmental variables can be systematically varied with equal ease. Of course, advantages such as these cannot enable the elimination of animals from the study of behavior. There can be no behavior analysis without behavior. Computer simulations are means for analyzing behavior, not replacing it.

Shaping via a Win-Stay strategy. Two features of the explanation of shaping across a Long Key using a Win-Stay strategy should be noted. First, the effects of reinforcement on the Calliope model are extremely short term. The consistent performance over time indicated in the Figures are due to the consistencies in the environmental contingencies, not due to any "memory" in the model. Second, there is no reason in principle why the present model could not be expanded to deal with more long term changes. Separate sets of emitter units could be constructed, each tied to separate stimulus complexes. Sodium activation would only occur in the emitter set corresponding to the current stimulus complex. Without activation, thresholds in the other sets would be held constant until the appropriate stimulus complex recurred.

Success as failure.

The success in matching the model's

prediction to the experimental data seems like a good thing. The model has failed to be disconfirmed. The difficulty is that many things of importance happened in the experiment. A computational model of this type is intended, ideally, to account for all of them. The only information we have about the many things that happened in the original experiment are the measures included in the published report. In the present case, these consist of the graphs of within-subject response frequencies by session and the ratios of reinforced responses to responses across subjects for different conditions. Even if the model were able to match these values exactly in all cases, the absence of raw data from the experiment severely limits the ability to thoroughly test the model.

Ideally, in the future, neural network modelers will work together with experimentalists to permit a wide variety of direct comparisons of various measures of the experimental data to the model's predictions. The simultaneous availability of raw data from both experiment and simulation will enable much more effective evaluation of artificial neural network models.

Conclusion.

That the cyberpigeons outperformed the real pigeons is a success for the win-stay model of this type of shaping, but a failure for the neural network. Specific implementation of a general model as a neural network substantially increases the number of parameters available to produce a precise fit to the data. More effective learning by the neural network than by the real organisms is somewhat unusual, but still counts against the fit of the neural network to the data.

One possible explanation for the difference in control over the locations of real and simulated keypecks is the model of motor movements in the In Situ testbed. In the context of a win-stay/lose-shift strategy, cyberpigeons could only shift one key, either left or right. Real pigeons, confronted with a non-reinforced keypeck might move much further than one key (0.5 in.). Situated in this way, the neural network might be expected to exhibit less variability after a non-reinforced keypeck than a real pigeon. This would account both for the lower initial effectiveness of longer step sizes as well as the greater effectiveness of reinforcement overall. This interpretation illustrates that the modeling of aspects of organism-environment interactions outside of the organism's central nervous system may be as critical to modeling success as the neural network itself.

The neglect of shaping in the experimental literature (Lindsley, 1996) has been followed by similar neglect in the modeling literature (Gullapalli, 1997; Kemp & Eckerman, 2000). An important reason for this neglect is that, in shaping, the definition of a criterion response changes within a space of possible response topographies. When modeling restricts itself to the occurrence or non-occurrence of criterion responses, there is no way to model this key feature of shaping. A formal analysis of the relation between motor activity and criterion response, such as that provided by the In Situ testbed, permits computational models to address questions in this critical area.

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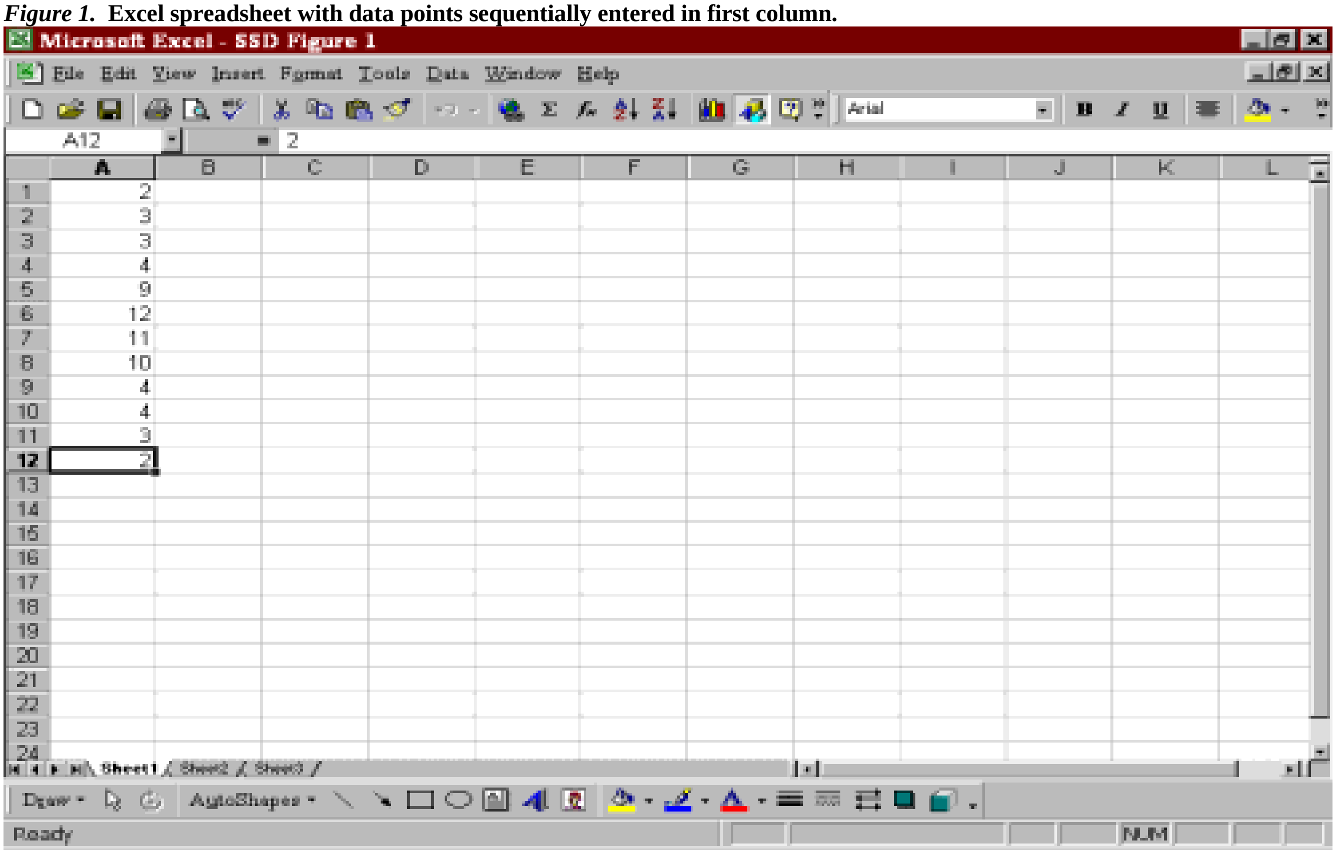
CONSTRUCTING SINGLE-SUBJECT REVERSAL DESIGN GRAPHS USING MICROSOFT EXCEL™: A COMPREHENSIVE TUTORIAL

Daniel J. Moran Brian Hirschbine
Valparaiso University

Single-subject reversal design graphs are critical elements to research in behavior analysis. This technical tutorial gives thorough instructions for creating a reversal graph with Microsoft Excel 97 & Microsoft Excel 2000 for Windows. Following these step-by-step instructions will yield graphs that conform to the *Manuscript Preparation Checklist* in the *Journal of Applied Behavior Analysis* (2000).

Repeated measurement of the behaving of a single subject in changing contexts is fundamental to behavior analysis research. Single-subject design methodology (a/k/a time-series methodology, n=1 research, intrasubject replication) can be applied, not only to research, but also in interventions to support treatment decisions (Hayes, Barlow, & Nelson-Gray, 1999) and replace subjective clinical judgment (Moran & Tai, 2001). Graphic representation of behavior change data is critical to this endeavor, and can be accomplished using Microsoft Excel's spreadsheet and graphing functions. The graphs produced by this tutorial will conform to the *Manuscript Preparation Checklist* in the *Journal of Applied Behavior Analysis* (2000).

Figure 1. **Excel spreadsheet with data points sequentially entered in first column.**



DATA ENTRY

To begin, open a blank Excel spreadsheet and enter the data vertically, starting with the first data point in the top left cell (A1) and continue downward, sequentially entering all data points in this first column (see Figure 1). In this example, there are four baseline data points (2,3,3,4), four treatment data points (9,12,11,10) and four reversal data points (4,4,3,2). When all data are entered into column A,

Figure 2. **Separating the treatment and reversal data from the baseline data into the second column.**

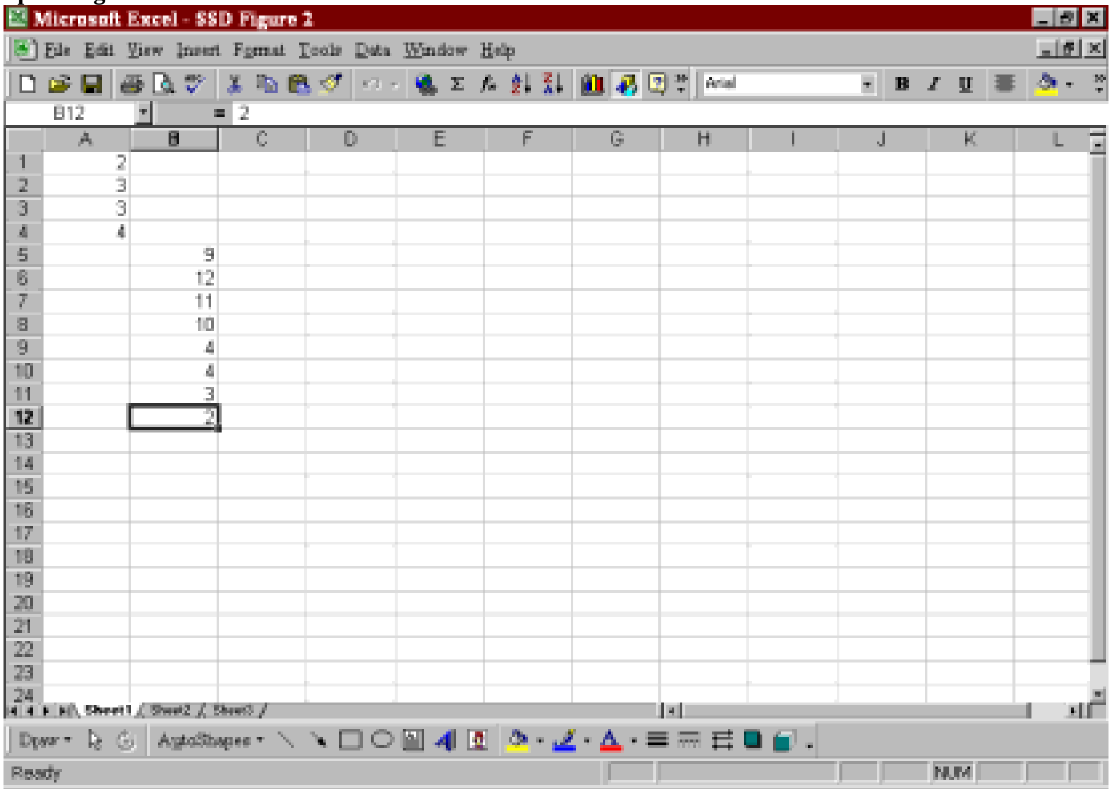
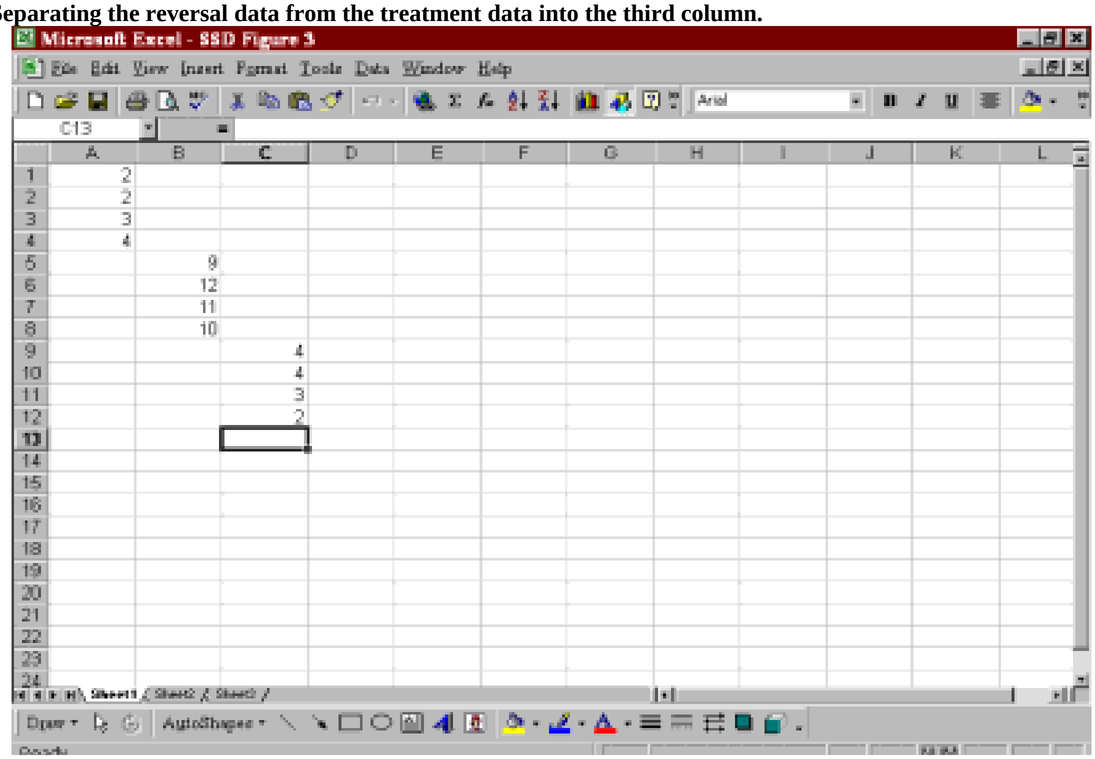


Figure 3. **Separating the reversal data from the treatment data into the third column.**



the data must be separated by their phase in the treatment (or experiment). In the Excel program each column represents a phase in the treatment and each row represents the time of the measurement.

To distinguish the phases of the intervention (e.g., Baseline, Treatment, Reversal, etc.), separate the single column of data into as many columns as there are phases in the experiment. Simply, when the data from a given phase end, that is where data in the

***Figure 4*. Highlighting the data.**

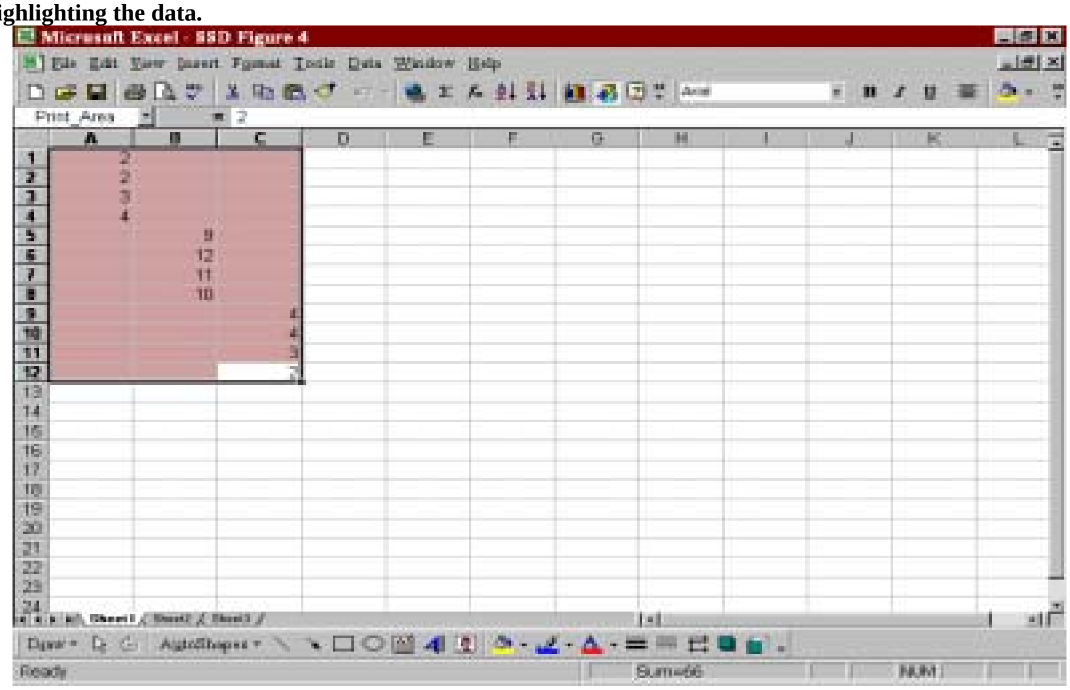
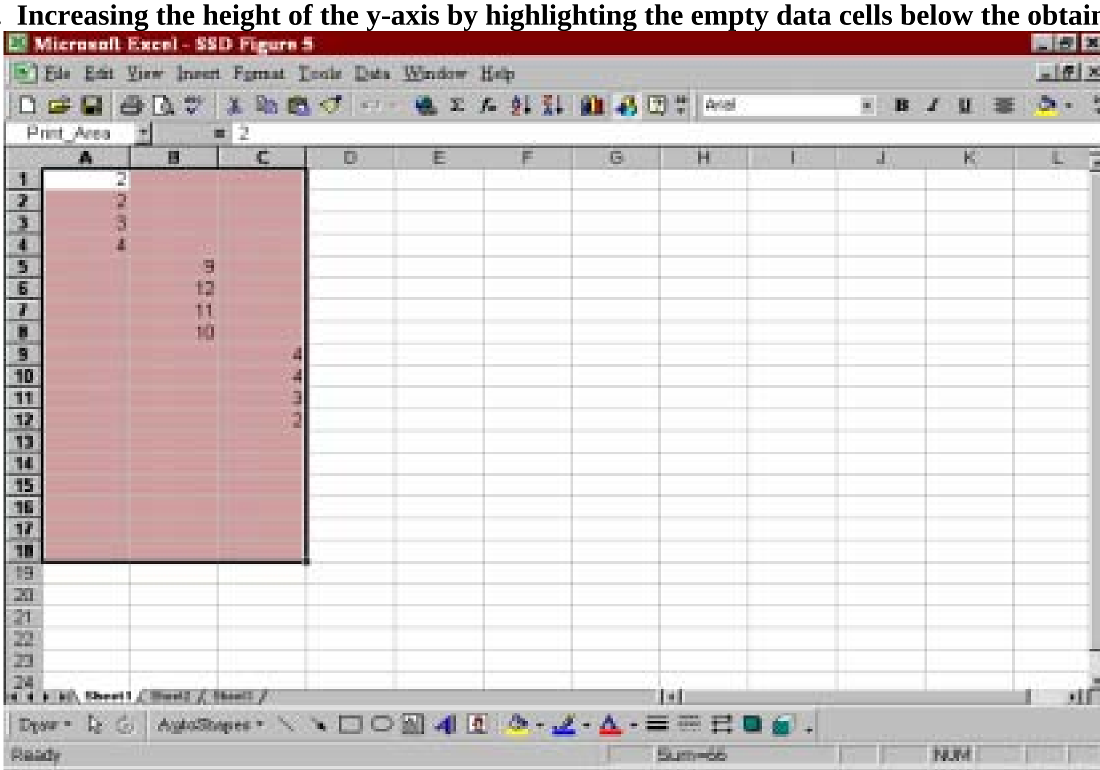


***Figure 5*. Increasing the height of the y-axis by highlighting the empty data cells below the obtained data.**



column should end, too. To separate the data into phases that are distinguishable on the resulting graph, move all entries for that particular phase of the treatment into the column immediately to the right, beginning in the row immediately below the last entry point of the column before (see Figures 2 & 3).

CUTTING AND PASTING

To move the data from the first column, use the *cut* and *paste* options of Microsoft™. To use the *cut* and *paste* options, highlight the data entries you would like to move for each phase. To highlight, simply place the mouse pointer (which will look like a large plus sign: "+") at the beginning of the first entry point you wish to select, hold down the left button on the mouse, and slowly move the mouse downward. "Highlighting" will cause the cells to turn black or light brown. As long as you hold down the left mouse button you can continue to highlight and change the range of data that you want highlighted. Once the data you wish to move are highlighted, release the left button of the mouse. The data set you selected should still be highlighted. Move the mouse pointer anywhere in this highlighted area, then press and release the right mouse button. This is known as "right clicking." A window will appear. Move the mouse pointer to the option of "Cut" in the window, and once the option is highlighted, press and release the left button of the mouse. This is known as "left clicking." Once the data have been *cut*, the data entries that were highlighted will have a border of moving lines around them. (There are a few ways to perform the *cut* and *paste* functions with Microsoft Software, and individuals familiar with these applications may use those methods). To *paste*, move the mouse pointer to the cell where you want the data to begin and "left click" that cell and then "right click" on that same cell. The same window will appear that did when *cutting*, and "Paste" can be selected. Choose "Paste" by left clicking. The data surrounded by the flashing border will disappear and reappear in the cells of the column selected. Repeat these steps as necessary to complete the number of phases required in your treatment. The spreadsheet should look similar to Figure 3 when completed.

Preparing the Graph with the Chart Wizard

Once the data are entered in this manner, highlight all of the data to be represented in the graph. To do this, start with the mouse pointer in the upper left hand corner inside the spreadsheet (i.e., at A1). Press and hold the left mouse button to highlight the data. Drag the mouse down and to the right to encompass all the data within the highlight. Empty cells will also be highlighted (see Figure 4), but will have no effect on the graph as long as the empty cells do not exceed the parameters set by the rows and columns. If you wish to add extra height to the y-axis (to represent greater "ceiling" for data variation), highlight empty cells in the rows below the data. Compare Figure 4, which encompasses only the data, to Figure 5, which adds six extra rows and will add greater height to the y-axis.

After the data are highlighted, the graph can be created. Move the mouse pointer to the toolbar above the spreadsheet. Here you will choose the "Chart Wizard" icon, which is represented by a blue, red, and yellow bar graph. In Figure 6, it is the third icon from the right. Click this icon and a window will appear labeled "Chart Wizard- Step 1 of 4- Chart Type" (see Figure 7). Under the "Standard Types" tab you are offered the options of "Chart type:" and "Chart sub-type." In the "Chart type" window select "Line." The information in the "Chart sub-type" window will change and the chart used for single-subject design (SSD) graphs is most likely the default option. The default is highlighted and the colors are altered compared to the other options. If the default has not been selected or has been changed, select the "Chart sub-type" option in the first column and middle row. You will know that this is the right option if the window below the "Chart sub-type" option reads, "Line with markers displayed at each data value." Once this option has been highlighted, left click the "Next >" button at the bottom of this window.

A new window will appear labeled "Chart Wizard- Step 2 of 4- Chart Source Data" (see Figure 8). Under the tab "Data Range," a preliminary example of the SSD graph will appear in the top of the window. Under the graph a string of coordinates will appear next to the label "Data range:" (i.e., "=Sheet1!$A$1:$C$12"). For a SSD treatment with only one measure, this window is unnecessary. You may proceed without changing anything in this window by left clicking the "Next >" button.

A window labeled "Chart Wizard- Step 3 of 4- Chart Options" will appear (see Figure 9). The default setting will first select the "Titles" tab. If the default has been changed, select the "Titles" tab option now by left clicking on it. There will be a series of three boxes on the left side of the window. Click in the empty box labeled "Chart title:" and a cursor will appear allowing you to type in the title of the graph. In figure 9, notice that "Name of your graph" has been typed in the box underneath "Chart title:" and that "Name of your graph" also appears above the graph prototype to the right. There is no limit on the length of the title because the graph shifts sizes to accommodate it. When the title is complete, *do not* press Enter because the window for the next step will appear. Rather, use the mouse pointer to select the second box labeled "Category (X) axis:" Clicking on the empty box will cause a cursor to appear, allowing you to enter the label for the x-axis. You can repeat these steps with the "Value (Y) axis:" box to label the y-axis.

Next, click on the "Axes" tab next to the "Title" tab. The defaults for this tab ("Automatic") are within the acceptable parameters of a SSD graph. However, should you desire dates along the x-axis instead of numbers, this option can be changed here by selecting the "Time Scale" category under the "Category (X) axis" label.

Select the "Gridlines" tab next to the "Axes" tab. A conventional SSD graph requires no gridlines, but the default of Excel includes major gridlines on the Y-axis. Remove these lines by left clicking on the check-marked box labeled "Major gridlines" under the title "Value (Y) axis:" (see Figure 10).

The "Legend" tab located next to the "Gridlines" tab allows you to reposition the legend in the chart. However, most SSD graphs with one measure do not require a legend, and it can be removed by left clicking the check-marked box next to "Show legend." This will remove the check mark default and the legend will disappear from the preview graph located on the right hand side of the window (see Figure 11). The following tabs, "Data Labels" and "Data Table" allow you to label the value of each data point on the graph and to include a table of data from which the graph was developed. Neither of these functions is necessary for most conventional SSD graphs and these tabs may be ignored. To proceed, left click the "Next >" button.

The window labeled "Chart Wizard- Step 4 of 4- Chart Location" allows you to have the graph appear on a separate page in the Excel application or as an object on the same page as the spreadsheet containing the data. In order to see the data and the graph at the same time (i.e., as an object in the spreadsheet), the default "As object in:" is

***Figure 6.* The top tool bar contains the Chart Wizard icon, which is the third icon from the right, and the Drawing icon, which is the second icon from the right.**

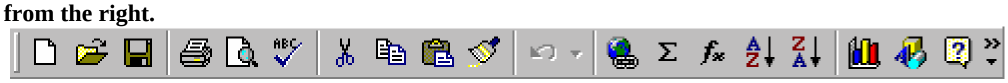
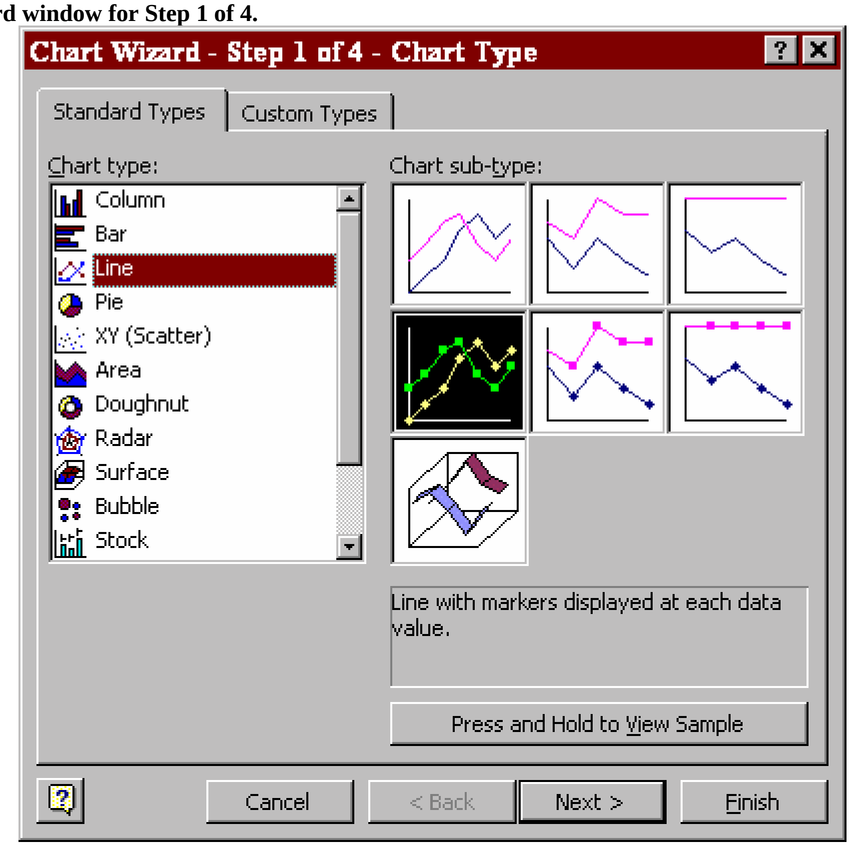


***Figure 7.* Chart Wizard window for Step 1 of 4.**



recommended (see Figure 12). Left click the "Finish" button with the mouse pointer.

The graph will now appear as you designated in the final step of the Chart Wizard. If the default, "As object in:" was selected and the graph obscures the raw data, you can move the entire graph. To do this, move the pointer (which will look like an arrow when inside the graph) to the white border of the graph. Leave the pointer motionless for one second and a label reading "Chart Area" will appear. Once you are on the Chart Area, left click with the mouse and continue to hold down the left button. You can now drag the graph to the desired location on the page. Once you have the graph where you would like it placed, release the button.

You may notice that the metric of the y-axis has changed. While constructing the graph in the Chart Wizard, the range was from zero to 14 and increased by two (see Figure 11). Now that the graph is complete, the metric has automatically changed. This unfortunate "glitch" can be ameliorated while customizing the y-axis.

CUSTOMIZING THE GRAPH

It is prudent for the y-axis "zero line" to be raised, so the x-axis line does not obscure any zero data points. The JABA *Manuscript Preparation Checklist* also requires lifting the y-axis zero line. In order to make data points with a zero value rest above the x-axis, double click the y-axis line. (If you let the mouse rest for one second near the y-axis, and a window will read "Value Axis"). Once you have double clicked this area, a window will appear entitled "Format Axis." Select the "Scale" tab of in this window by left clicking on it. (Figure 13) Under the "Scale" tab, remove the defaults that are set by check marks in the boxes under the heading of "Auto." To remove, left click on each check mark and it will no longer appear in the box. Now, change the value in the "Minimum:" box from "0" (zero) to "–2." This will give the y-axis zero line a relatively higher position on the axis. To do this, highlight the "0" entry and press the delete key on the keyboard, then type in "–2." Next, change the number in the "Maximum" box to the highest value you would like to assign to the y-axis. The current graph will have a "ceiling" of 14. If you would like to present a graph with a greater "ceiling," choose a number that significantly exceeds the highest data point. Now change the "Major unit," which sets the y- axis metric, with the same technique used to change the "Minimum." For example, if you want the y-axis to progress "by twos," put "2" in this window. This metric can be varied depending on your data and presentation preference. Next, define where the x-axis crosses the y-axis by changing the value in the box labeled "Category x-axis Crosses at:." Delete the number "0" and change it to the "Minimum" value (i.e., "-2"). The "Minor unit" can be ignored for most graphs. The "Format axis" window should look like Figure 14. When you are following these directions for your own data, some of the aforementioned values may not suit your graph. Constructing an appropriate y-axis for different data values may require "trial and error."

The graph will automatically change to the programmed values. However, you will notice that the abscissa is labeled "–2." A negative value on the y-axis is unsuitable for most behavioral graphs and must be eliminated. (It seems absurd to imagine a behavior occurring –2 times during a sampling!) Removing this label will require, as stated by Carr & Burkholder (1998), "some electronic sleight of hand" (p. 247). The entry needs to be covered because it is a permanent part of the graph and cannot be deleted. You must cover the "-2" with a blank text box. To get to the "Text Box" option, you need to use the "Drawing" tool bar (see Figure 15). This tool bar is at the bottom of the spreadsheet. If it is not on the screen, you can make it appear by left clicking on the "Drawing" icon, which is located on the top toolbar directly to the right of the Chart Wizard icon. This icon is symbolized by a large blue "A," a yellow square, and a light blue cylinder (see Figure 6). Once you left click the Drawing icon, a bar will appear at the bottom of the spreadsheet. The "Text Box" icon is in the middle part of the tool bar, five icons to the right of "AutoShapes," and is symbolized as a lined sheet of paper with a blue "A" in the upper left-hand corner. After left clicking the icon, the cursor of the mouse will resemble an upside down lower case "t." Move the cursor just above the upper left hand corner of the "–2" entry. Left click and hold the button to set one corner of the text box. By moving the mouse, you can define the size of the text box. After the text box completely covers the "–2" label, release the left mouse button, and a text box will appear (see Figure 16). Notice that a bold dot matrix border defines the text box. Double click on this border and a window will appear labeled "Format Text Box" (see Figure 17). Select the tab, "Colors and Lines" and then under the category of "Fill," the option of "Color:" will be set as "No Fill" by default. Left click on the downward arrow next to the box reading "No Fill," and you will be presented with an array of colors where you will be able to change the color of the text box. Click on the white square, which is in the bottom right corner of the top array of colors. Under the category of "Line," the "Color:" option default will read "No Line." Again, click on the downward arrow to open the color array. In this array, click on the white square in the bottom right corner of the top array of colors. Now select the tab of "Margins" in the "Format Text Box" window. You will want to remove the default of "Automatic" by left clicking the check marked box next to the option so that there are no margins displaying this text box. These three steps will make the entire text box white and will obscure the "-2."

Now select the tab of "Properties" within the "Format Text Box" window and select the option, "Size with chart" by left clicking on the circle next to the option (it may be set as a default). If you do not select this option, the text box will not appear when you print the graph. Only those text boxes formatted to size with the chart will appear when the graph is printed. Those not formatted to "size" will be lost as the image of the graph covers them. Then make sure there is a checkmark in the box next to "Print object" so this blank text box is printed over the "-2" label. Left click the "OK" button at the bottom of the screen to return to the graph. Click the mouse anywhere in the Chart Area to make the dot matrix text box disappear.

Now that the axes are accurately defined, you can add the phase lines of your treatment to the graph. In the "Drawing" toolbar, select "AutoShapes." Selecting this category will bring up a new window where you will choose the option, "Connectors" (see Figure 18). If you do not see the "Connectors" option, you need to expand the window by clicking on the double arrowheads pointing downward in order to show all of the options. When you left click on "Connectors," a new window will appear. This gives you a number of options, however, the one to select is the first option located in the upper left hand corner of the window. Once this is chosen, the mouse pointer will resemble a small plus sign: "+." Place the intersection of this "+" pointer on the x-axis directly between the phases. When you left click on the x-axis, the base of the phase line will be set in this location. You can now move the line by moving the mouse. You will want to move the line and the "+" pointer to the top gridline of the y-axis. When you left click again the line will be in place. Make sure that the line is vertical and straight, as Excel does not do this automatically. You can adjust the line by clicking on the small boxes on either side of the phase line and moving the mouse. This procedure will create a solid line (see Figure 19). Phase lines are more appropriately dotted lines, so to change the phase line appearance, *right click* on the connector line and a window will appear. Select the option of "Format AutoShapes" with a left click (see Figure 20). Under the "Colors and Line" category notice that the "Dashed:" option displays a solid line. To change this, left click on the downward arrow next to the option, which will bring up a new window presenting different types of line formations. Select the broken line (fourth from the top) for the SSD graph by left clicking on that option and then select "OK" at the bottom of the larger window. The dashed phase line is now in place. Repeat all of these steps, starting from clicking on "AutoShapes" to begin using the "Connectors," for all the required phase lines.

LABELING PHASES

To label the phases in your study or treatment (i.e. Baseline, Treatment, Reversal, etc.), use the "Drawing" toolbar to use the "Text Box" option again. This time, put the text box (using the same technique described for concealing the "–2" on the y-axis) above the graph, but within the phase parameters set by the phase lines. This placement is suggested by the JABA *Manuscript Preparation Checklist* (see Figure 21). Be sure that the text box is large enough to fit your label. If the text box cannot contain the phase label, you can change the font of the label so that it will fit. To do this, double click on the dot matrix border of the newly positioned text box. This will bring up a "Format Text Box" window where you can select the "Font" tab by left clicking it. Under the category of "Size:" in the far right of the window, enter the size of the font as you want it to appear. When you have entered the numerical size, left click the "OK" button to close the window. Getting the size appropriate for your graph may require "trial and error," and depends on the size of your phases. Make sure the text box is large enough to fit all the words. If it is not, you can expand the text box by clicking on the small squares on the borders of the box, holding down the button and "stretching" the box to size by moving the mouse. If you want to move the text box, click on the border of the box (but not on the small squares), hold down the button, and move the box by moving the mouse.

After you have adjusted the font for the phase label, remember that each new text box must be formatted to "Size with chart," under the "Properties" option or the labels will be lost when printing. This format is likely to be the default. When this is secured, click the mouse outside of the text box to affix the addition. This will make the bold dot matrix border disappear. (Pressing "Enter" while the text box is enabled will only bring you to a new line under the line just typed. If the text box is small, it may look as if the words you just entered have disappeared.) You can make as many phase labels as you need, but you are limited to the space within your graph (i.e., do not make the labels so large or numerous that they obscure the data).

Putting the subject's name or identification on the graph required the same procedure, except that such text usually has a surrounding border. Many SSD graphs place the subject's name or identification in the right bottom corner of the graph. To accomplish this, follow the aforementioned procedure for entering phase line titles, but while in the "Format Text Box" window (which you can access by left clicking the text box border), select "Colors and Lines" and then under the "Line" category click the downward arrow next to the box labeled "Color:" in order to make the color array appear. Click on the black box in the upper left corner of the top color array and then left click "OK." When you left click anywhere outside of the text box, the dot matrix text box border will disappear, but there will be a black frame around the name that you typed (see Figure 22).

To remove the black border and gray coloration from the Plot Area, place the pointer in the gray area for one second and a label reading "Plot Area" will appear letting you know you are in the right place. Double click this gray area and a window labeled "Format Plot Area" will appear. There is only one tab labeled "Patterns" and under the tab there will be a category labeled "Border." Choose the option "None" by left clicking the empty circle next to it. This will remove the black border around the chart area. Next, move to the category of "Area" located directly to the right of the "Border" options and choose the option, "None," by left clicking the empty circle. Now, left click on the "OK" button at the bottom of the window to close it. Left click the mouse somewhere in the Chart Area and the gray background and frame around the plot area will disappear.

Next, remove the border from the Formal Chart Area. Move the pointer to the outer edges of the graph and leave it motionless for one second. A label reading "Chart Area" will appear. Double click the mouse and a window labeled "Formal Chart Area" will appear. In the first tab labeled "Patterns," under the category of "Border," choose the option "None." This will remove the border from the graph. You may not notice a change on the computer screen, but it will make a large difference when printing out the graph. You may also change the font of the graph labels by choosing the next tab, "Font" within this window. However, the 10-point Arial default is appropriate for most journals and presentation styles. The "Properties" tab has no function for graphing purposes, but is designed for presentation of the graph in the Excel program. Left click the " OK" button at the bottom of the window.

Journals present SSD graphs with black lines and black dots on a white background. To change graph to black and white only, place the mouse pointer on the first data series. This line, by default, should be dark blue. Leaving the pointer still for one second will bring up a window reading "Series *the name given to this phase*." Double click on the line and a window will appear entitled "Format Data Series." Under the tab "Patterns" there are two categories: On the left is "Line" and on the right is "Marker". Under the "Line" category, left click on the empty circle next to "Custom." The "Style" option allows you to choose how the line will appear. You have the choice of solid, broken/dotted, and broad (this can be checkered, solid with empty dots, or empty with solid dots). The most appropriate choice for SSD graphs will be the solid thin line, which is likely to be the default. Change the color of the line by left clicking the downward arrow next to the "Color:" box. Left click on the black square in the upper left corner of the top color array. The "Weight" option allows you to choose how thick the line will appear and the default setting is most appropriate. To change the markers along the line graph, move the pointer to the "Marker" heading and simply select the option of "Custom" by left clicking on the empty circle next to it. Left clicking on the downward arrow next to the "Style" option allows you to distinguish what shape the data point markers will take. Although Excel offers a large variety, a circle marker is most appropriate for the SSD graph. The

"Foreground:" option allows you to choose the color of the marker border. Choose a black border by left clicking the downward arrow next to the "Foreground:" box and left click on the black square in the top left corner of the top color array. The "Background:" option allows you to choose what color the face of the marker will be. Select black by using the aforementioned method of changing colors for the foreground. The " Size" option at the bottom of the "Marker" category allows you to determine how large the marker will be on the graph, and the default size (7 pt.) is typically appropriate. Click "OK" when the data series is formatted to black and white. Repeat this process for each data series in the graph so that there are no colors on the graph. Your graph is now complete (see Figure 23).

PRINTING THE GRAPH

Printing the graph within appropriate dimensions requires a few more steps. Select the "File" pull-down menu from the top tool bar and then select the option of "Print Preview." This will open a new screen with a complete layout of your graph, which takes up the entire page. This is exactly how it will look if you were to print it. For most journal submissions, you will need to reduce the size of the graph. In the tool bar across the top of the screen, notice the button labeled "Margins." Left click this button once. You will notice that four lines have appeared around the perimeter of the graph. When you place the mouse on one of these lines, the pointer changes shape from the normal arrow to a cross-shaped figure with arrows pointing left and right if the pointer is on a vertical perimeter line or up and down if it is on a horizontal perimeter line. By left clicking on these lines and holding the button, you can set the margins by "dragging" and "dropping" the lines. However, there is another way to do this. In the top toolbar, to the left of the "Margins" button, find the button labeled "Setup…" and left click this button once. A window will appear labeled "Page Setup" with a number of tab options across the top. Left click the tab, "Page." In this option, change the page layout from "Landscape," the default in Excel, to "Portrait," the more appropriate option, by left clicking the empty circle next to the "Portrait" option. Now the graph will appear vertical and centered on the screen and print this way on the paper. Next, select the "Margins" tab. The window will now show an image of a mock graph surrounded by six open option boxes labeled clockwise from the left: (Left:, Top:, Header:, Right:, Footer:, Bottom:). By entering numbers in these boxes you can automatically set the margin in inches. The "Header" and "Footer" values are set at an appropriate default of .5 inches. To make the graph approximately 4 inches x 5 inches, set both the "Left:" and "Right:" option to 1.75 inches. Then set the "Top:" and "Bottom:" options to 3.5 inches.

If you would like to add a header to the page, click on the Header/ Footer tab on the same "Page Setup" window. Here you can add your header (figure number, running head, page number, etc.) by left clicking the "Custom Header..." button in the middle of the window. Another window will open which separates the header into "Left," "Center," and "Right" sections. Left click in any section and type what you would like to appear. Once your header is complete click on the "OK" button in this window and then left click "Close" from the top tool bar in this "Print Preview" window.

To print the graph, select the "File" pull down menu from the top tool bar and then select the "Print" option, which has a small icon of a printer next to it. A window labeled "Printer" will now be on the screen. This window allows you to select which printer you will be using and the number of copies you want. Once you have selected these parameters, left click the "OK" button at the bottom of the window and a SSD graph will be printed and publishable.

Your graph constructing behavior will be appropriately rule-governed with this tutorial, but as your data or designs become more complex, contingency shaping will be in effect. In other words, these instructions are a good starting point, but you should be flexible in your adherence to them when you are building new graphs.

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COMPARISON OF WITHIN-STIMULUS AND EXTRA-STIMULUS PROMPTS TO INCREASE TARGETED PLAY BEHAVIORS IN AN INCLUSIVE EARLY INTERVENTION PROGRAM

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Limited participation and sampling of stimuli by children in early childhood programs may restrict opportunities to respond and limit learning. The purpose of this study was to extend the concept of within-stimulus prompting (Schreibman, 1975) for use in an early intervention classroom to occasion play with previously low-contact toys in previously low-contact centers for two children. Kaitlyn was 27 months old and diagnosed with Down syndrome. Greg was 29 months old and diagnosed with autism. A reversal design was used to evaluate experimental conditions. For Kaitlyn, adult prompting more effectively occasioned toy play. For Greg, the within-stimulus prompt effectively occasioned play with planted stimuli in previously low-contact centers following the within-stimulus with adult prompt phase and return to baseline.

Maximal intervention growth in early intervention classrooms is likely to depend at least in part upon full participation and sampling of multiple stimuli (i.e., toys and activity centers). When a child exhibits low levels or highly restricted patterns (e.g., toy choices) of play in a classroom, the child may receive a restricted range and number of learning trials or opportunities to respond. Therefore, early childhood programs serving children with disabilities often seek ways to improve child participation and contact with stimuli across multiple activity centers in the classroom (e.g., blocks and manipulatives, computer, dramatic play, and reading centers).

Adult prompting is well established as an effective training strategy (Wolery, Ault, & Doyle, 1992), and is commonly used to occasion toy play, speech, and other behaviors in early childhood settings (e.g., milieu teaching, incidental teaching). Effective adult prompting procedures require a child to attend to the programmed adult prompt or discriminative stimulus (e.g., “Sean, go to the sand table”) while simultaneously discriminating the naturally-occurring stimuli (another child leaves sand table creating an opening there). Correct independent performance of the skill necessitates transfer of control from the adult prompt to the naturally-occurring discriminative stimulus, a process that may produce an increase in errors, at least initially.

In contrast to adult prompting, within-stimulus prompting (Schreibman, 1975) manipulates criterion-related cues to establish correct responding (e.g., carpet squares are used around the sand table for children to stand on, when a child leaves the sand table a carpet square is empty). Once correct responding is established, the cue can be faded (e.g., size of carpet square is gradually reduced until absent) so that the only remaining distinction is the criterion distinction (i.e., open spot at the sand table). Because within-stimulus prompting involves a relevant part of the training stimulus, it may effectively establish the response when the child attends only to a relevant part of the training stimulus. Thus, within-stimulus prompting may result in errorless transfer. That is, within-stimulus prompting does not require a transfer of control from a programmed prompt that is not intrinsic to the activity and allows for gradual, deliberate fading.

Several investigators have demonstrated the potential utility of within-stimulus prompts to establish correct responding (Mosk & Bucher, 1984; Repp, Karsh, & Lenz, 1990; Schreibman, 1975). Schreibman compared the effectiveness of extra-stimulus (adult prompting) to within-stimulus prompting (stimulus shaping) to train auditory and visual discriminations with six children with autism. Schreibman found that participants always required a prompt to learn the discrimination and the within-stimulus prompting procedure effectively established auditory and visual discriminations whereas extra-stimulus prompting did not for most of the children. Mosk and Bucher used an alternating treatments design to compare the effectiveness of a stimulus-shaping with prompting procedure to a standard least to most prompting package (i.e., present criterion-level skill, use sequenced prompt to compliance, and deliver social and edible stimuli following each trial). In all cases, the stimulus-shaping with prompting procedure was more efficient (required fewer trials and produced fewer errors), was less restrictive (required less adult prompting), and resulted in increased delivery of edible and social rewards.

Similarly, Repp, Karsh, and Lenz (1990) compared the effectiveness of a stimulus-shaping procedure to a standard least-to-most prompting hierarchy to teach visual discriminations of numbers. They found that the stimulus-shaping produced more correct unprompted responses, fewer errors, and greater contact with tangible rewards and social praise across all phases including a generalization phase with altered stimuli in the *training* setting, a second generalization phase with altered stimuli in the *classroom* setting, and a maintenance phase conducted 6 months after study completion. One common characteristic of these studies is that they were conducted in analogue settings.

The purpose of this study was to compare the effectiveness of within-stimulus and extra-stimulus prompts to increase targeted toy play behaviors and maximize opportunities to respond for two children attending an early intervention preschool program. Specifically, the study was designed to examine the utility of toy alterations (considered the within-stimulus prompt) to occasion contact with previously low-contact activity centers and previously low-contact toys.

METHOD

Participants

Teachers nominated two children for inclusion in this study. Kaitlyn, 27 months old, was nominated based upon very low rates of toy play in the classroom. Greg, 29 months old, was selected for participation because he exhibited highly restricted play behavior. Greg played with toys in the classroom, but allocated almost all of his play to one or two toys in one or two activity centers. Kaitlyn was diagnosed with Down syndrome and Greg was diagnosed with autism. Kaitlyn had begun walking independently just before the study started. She typically followed verbal commands to perform self-care routines (e.g., remove socks and shoes, wash and dry hands). Kaitlyn did not use words to communicate, but did use gestures and some basic signs (e.g., more, no). She did not initiate play with peers, and exhibited stereotypy (shaking objects just within her field of vision). She was observed to imitate words on several occasions during the study (e.g., “baby”). The primary intervention goal for Kaitlyn was to increase toy play. Greg was ambulatory. He was observed to use words to request objects, but more frequently used gestures with vocal noises or crying to communicate. Greg’s teacher reported that he tended to enter only the computer and manipulatives centers in the classroom and that his play in those centers was highly repetitive (e.g., pressing a button to make a noise over and over with his face pressed close to the item). The primary intervention goal for Greg was toy play variation, including variation in the location of his play behavior. Thus, the primary goal for Greg was to establish and increase contact with previously uncontacted planted toys in previously low-contact centers.

MATERIALS AND SETTING

The classrooms were organized into activity centers (e.g., art, kitchen, manipulatives, dramatic play, computer). All sessions were conducted in each child’s classroom during one of the activity center choice periods of the day. During this time, children were free to choose the activity center where they would play. Adults staffed zones of the classroom to facilitate play and embed learning trials. Each classroom included approximately 12 children between the ages of 20 and 36 months and approximately five adults representing a variety of disciplines (e.g., early childhood special education, speech/language pathology, occupational therapy). Each classroom included about equal numbers of typically-developing children and children identified with disabilities. The children attended class for one-half day, twice weekly. A typical school day consisted of morning circle activity, center time, snack, outside play, center time, and end of the day circle activity. Toys were rotated in both classrooms according to monthly themes (e.g., dinosaurs, pets).

RESPONSE MEASUREMENT AND RELIABILITY

Table 1 summarizes the behavior definitions used in this study. A recording procedure was used that allowed data to be calculated as both partial-interval occurrence and responses per minute. Specifically, the observation form was divided into 60 interval blocks representing 10 s each and each behavior was assigned a numerical code. Observers noted the occurrence of a behavior each time that it occurred during an interval block. When the interval tape covertly cued the observer that the interval was over, the observer simply moved to the next interval block and continued noting the occurrence of behaviors as they occurred during the observation period. Continuous 10-min sessions were used throughout the study. Specific child behaviors recorded included center contact, toy play, planted stimulus contact, speech, and disruption. Specific adult behaviors recorded included adult attention and prompting. For an instance of child behavior to be considered prompted, an adult-delivered prompt would have occurred before the child behavior within the same or preceding interval. These data yielded responses per minute estimates of toy play, planted stimulus contact, speech, and disruption for each child. Percent interval center contact was computed for each center across sessions.

Table 1 - Behavior Definitions

Behaviors	Definitions
Planted Stimulus Contact	Child touches planted item with any part of his or her hand.
Toy Play	Child performs two actions (can be the same action repeated) on a toy using any part of the body within the same interval in a way that the toy was designed to be used by the manufacturer.
Speech	Gesture, vocalization, or word that is used to ask for help from a peer or adult or call adult's or peer's attention to an item or to point out features of an item or activity (includes imitation and naming objects).
Center Contact	Child touches material or furniture in a center for 2 s.
Adult Attention	Adult touches, talks to, or makes a facial expression to a child. Excludes adult prompts.
Adult Prompt	Adult tells a child to engage in a behavior, models a behavior for the child, or physically guides the child to perform a behavior. Excludes adult attention.
Disruptive Behavior	Kaitlyn- hand flapping for greater than 2 sustained s with or without an object that is not designed to produce noise when shaken. Greg- crying, self-injury

An independent observer simultaneously recorded data during approximately 33% of all sessions for each participant distributed across session type. Interobserver agreement (IOA) was calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying the resulting number by 100% for each observed behavior. Average agreement for all observed behaviors for Kaitlyn was approximately 92% (range 85% to 99%). Average agreement for all observed behaviors for Greg was approximately 94% (range 81% to 99%). Procedural integrity was monitored two ways. First, an independent observer observed and noted the occurrence of each scripted step of the experimental sessions (i.e., materials in their correct form, sampling conducted, choice board used if needed). Average procedural integrity across both children was 100%. Secondly, occurrence of adult prompts and adult attention were noted across all phases to allow for an estimation of the degree to which the teacher implemented the procedures as planned (e.g., delivered attention according to the prescribed schedule and did not deliver prompts during the stimulus alteration phase). Average integrity for Kaitlyn across all phases was 93% (range 72% to 100%). For Kaitlyn, procedural integrity was poor during the initial part of the stimulus alteration phase and may have contributed to variable responding during that phase (see Figure 4). Average procedural integrity for Greg was 97% (range 94% to 99%).

Stimuli and center selection. Teachers were asked to identify several ways toys might be altered in the classroom. In an attempt to ensure that items were not altered in ways that made them aversive to the participants, each child participated in a brief assessment (three, 5-min sessions) using toys with stimulus features identified by the teachers as potential alterations (Roane, Vollmer, Ringdahl, & Marcus, 1998). Toys were selected to present certain features including texture (koosh ball), light (light activated by a switch), noise (musical toy activated by a switch), light with movement (pinwheel activated by a switch), and vibration (vibrating pen). During one assessment session, Greg contacted the vibrating pen, cried, and did not interact with this item again. Kaitlyn did not contact the koosh ball during any of the assessment sessions. Thus, for both children classroom toys were altered to produce increased or augmented levels of noise, movement, and light. Textural or vibrating alterations were avoided.

Three, 10-min observation sessions were conducted during center time in the classroom to identify the centers where each child spent time playing or manipulating items. Kaitlyn contacted the dramatic play and manipulatives centers the least. Greg allocated most of his time to the manipulatives or computer center during preliminary observations. He contacted the kitchen and dramatic play centers the least. Thus, teachers were asked to select toys for each of the two centers contacted the least that were appropriate for their classroom, and could be altered to produce light, noise, or movement. Teachers were asked to not select toys that produced tactile stimulation when they operated or were manipulated (e.g., vibrating toys).

The selected items were placed in the centers in their inactivated forms for at least 1 month before inception of the study. Kaitlyn's teacher selected a piano (produced noises), driving toy (produced lights and noise), and Lite Brite™ (lights and noise) for the manipulatives center. Kaitlyn's teacher selected a flashlight (light), mirror with lights on an activation switch, and fan with activation switch (movement) for the dramatic play center. Greg's teacher selected a blender (produced noise and movement when activated), stove (produced noise when activated), and fork/spoon set (had transparent handles that were filled with sparkly items in liquid that moved when tilted up or down) for the kitchen center. Greg's teacher selected keys (produced noise when activated), cellular phone (produced noise when activated), and mirror with lights on an activation switch for the dramatic play center.

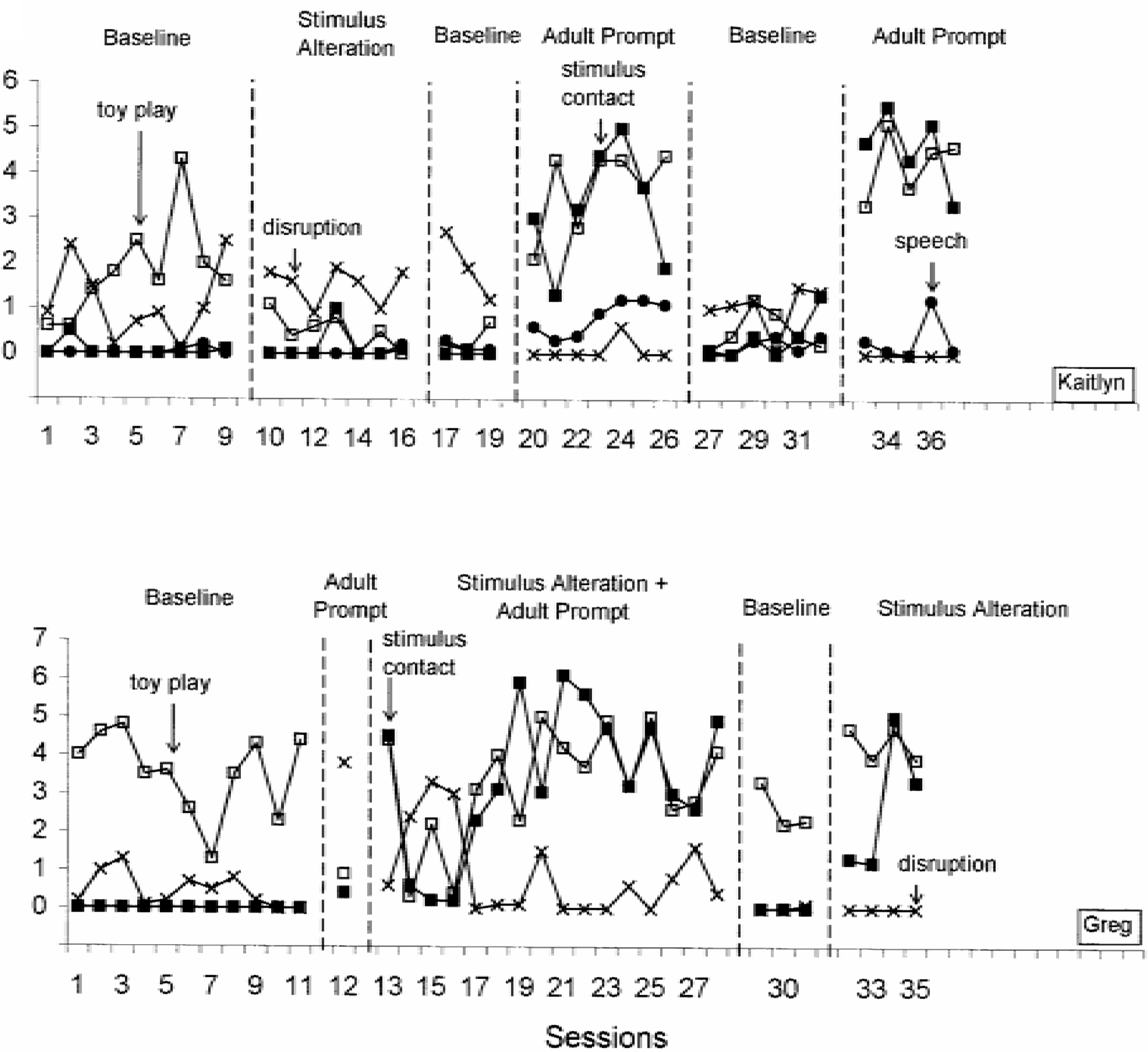
Experimental Design. The effects of each prompting procedure were evaluated for Kaitlyn using a reversal design (A-B-A-C-A-C). The primary dependent variable for Kaitlyn was responses per minute of toy play. The primary dependent variable for Greg was contact with the planted stimuli. Initially, a reversal design was planned for him, counterbalancing the order of phases with the other participant. When the adult prompt phase was initiated, however, Greg began to exhibit rates of tantruming that were upsetting to the classroom staff. The staff stated they would be willing to continue with the adult prompt procedure if the stimulus alteration component could be added. Thus, the adult prompt phase was discontinued prematurely.

Baseline. During baseline, four stimuli were placed in each of the two centers contacted least in their inactivated forms. To inactivate the stimuli, the power supply was removed or disconnected from the item. Smooth, opaque contact paper was used to cover the handles of the fork/spoon set for Greg. Each item could still be played with in its inactivated form (e.g., the handle of the blender could still be lifted up and items could be placed in the bowl of the blender). Before each session, the teacher guided the child to sample at least one of the inactivated items in each center for 2 s and briefly modeled manipulation of the other three stimuli. The teacher then placed the child in the pre-identified neutral starting point outside of the centers and stated, "You may play wherever you like. Go play." The teacher then waited 5-10 s for the child to begin moving toward a center. If the child did not move toward a center, the teacher provided the child a choice between one of the least preferred centers (rotated each session) and the last center the child was playing in before the session began using a choice board (i.e., Velcro board with a picture of the two centers). This choice procedure represented a standard practice in the classrooms where this study was conducted. That is, following transition to the center choice period, teachers typically prompted children using the procedure described above when children did not choose a center within approximately 5 minutes. No other programmed prompts or consequences occurred during baseline sessions. Following this phase, the cumulative amount of adult contact (i.e., adult attention and adult prompts) provided to each participant was divided by the number of sessions to yield an average amount of adult contact provided to each child per session during this phase.

Stimulus alteration and fixed interval yoked adult contact phase. During this phase, one of the stimuli in each center was altered for each session, whereas the remaining three items in each center remained in their inactivated form. Order of alteration was rotated and counterbalanced across phases of the study and centers (so each stimulus was paired an equal number of times with every other stimulus across the two centers). The sampling procedure was conducted as described in baseline with one exception. The child was guided to sample only the altered stimulus in each center for 2 s. During each session in this phase, the altered stimulus was activated throughout the duration of the session in each of the two centers (e.g., mirror lights turned on and blender making a constant blending motion and noise). The teacher attended to the child (i.e., neutral comment, praise, or physical touch) on a schedule that was yoked to the schedule of attention and adult prompts that occurred during the baseline phase (summed across all sessions and divided by the number of sessions to yield a per session average). The teacher was instructed not to deliver prompts during this phase.

Adult prompting and fixed interval yoked adult contact phase. In this phase, none of the stimuli were altered. The stimuli remained in the centers in their unaltered/baseline form. The sampling procedure was conducted as described in baseline. The adult prompted the child to exhibit one play response with the stimuli using a three step, least-to-most prompt sequence (verbal, model, physically guide) on a schedule that was yoked to the schedule of naturally-occurring attention and adult prompts delivered during the baseline phase. The adult was instructed not to provide neutral comments or other forms of attention (e.g., touching) during this phase except as necessary to deliver the prompt sequence (i.e., physical guidance necessarily required touching, a form of adult attention).

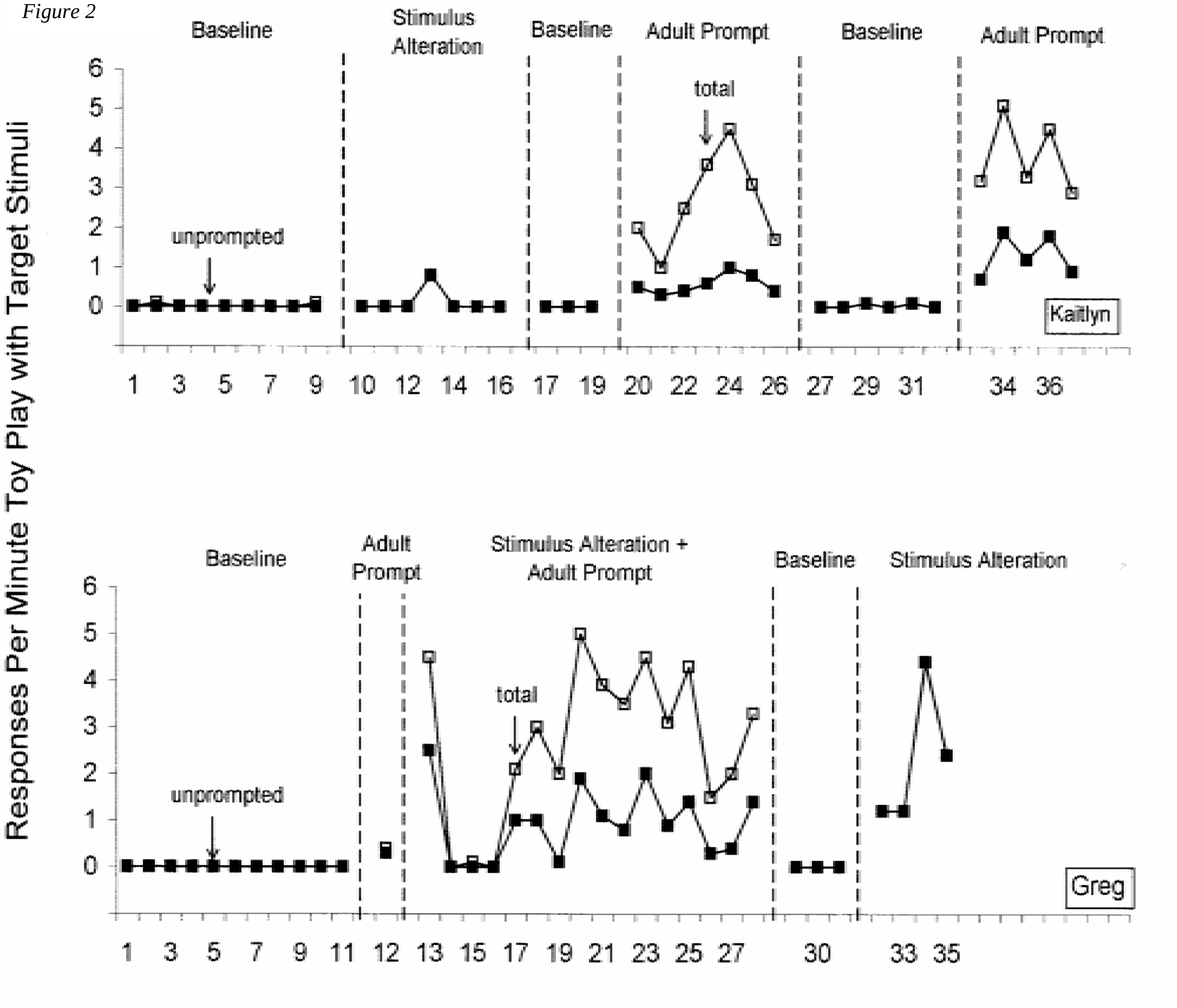
Figure 1



Combined stimulus alteration and adult prompt phase. In this phase, the stimuli were activated according to the rotating and counterbalancing plan used in the stimulus alteration phase. The sampling procedure was conducted using the procedures described in the stimulus alteration phase. In this phase, the adult delivered prompts using the procedures described in the adult prompting phase. Attention was yoked to the naturally-occurring attention and adult prompts delivered during the baseline phase.

Generalization probes. Greg was observed through a one-way mirror to determine whether or not he began to play in his least preferred centers outside of the experimental sessions.

Figure 2



RESULTS

Figure 1 shows responses per minute for the dependent measures across all phases for both participants. Figure 2 shows responses per minute, prompted and unprompted, with the planted stimuli across all phases for both participants. Figure 3 shows contact with the two previously low-contact centers for the two participants across all phases. For both children, unprompted play with the planted stimuli occurred at higher rates during the most effective treatment phase(s) relative to baseline and contact with previously low-contact centers was higher.

Kaitlyn

During baseline, Kaitlyn exhibited variable rates of play. On average, she played 1.8 rpm. During the stimulus alteration phase, she played an average of .5 rpm and played with the altered experimental stimuli only briefly during two sessions. During the second baseline, Kaitlyn exhibited low levels of toy play (*M*=.4 rpm) in general. During the adult prompting phase, Kaitlyn exhibited higher but still variable levels of toy play (*M*=3.7 rpm) in general. In the third baseline, toy play returned to low, variable levels (*M*=.5 rpm) comparable to that of the second baseline. Thus, adult prompting produced the highest levels of play for Kaitlyn. The open squares in Figure 1 represent toy play with any items in the classroom, whereas the filled squares represent play with the planted items in the low-contact center. When Kaitlyn was prompted to play in the adult prompting phases, she was prompted to play with the planted items. Figure 4 illustrates the relationship of adult prompting to rpm play for Kaitlyn, and shows the degree of procedural integrity. Specifically, the bars represent the responses per minute of *prompted* play across all sessions and phases, whereas the lines represent total rpm play across all sessions and phases.

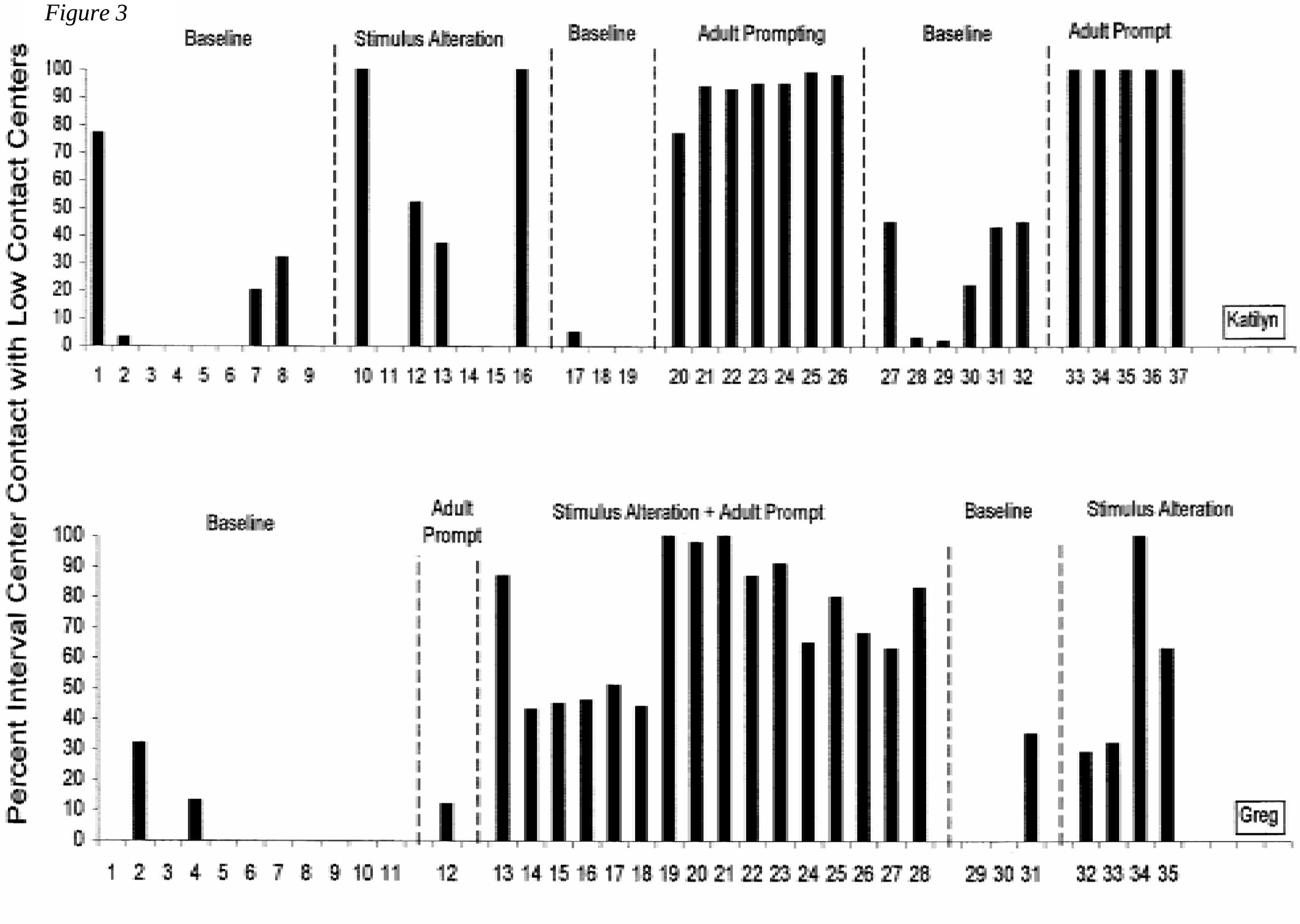
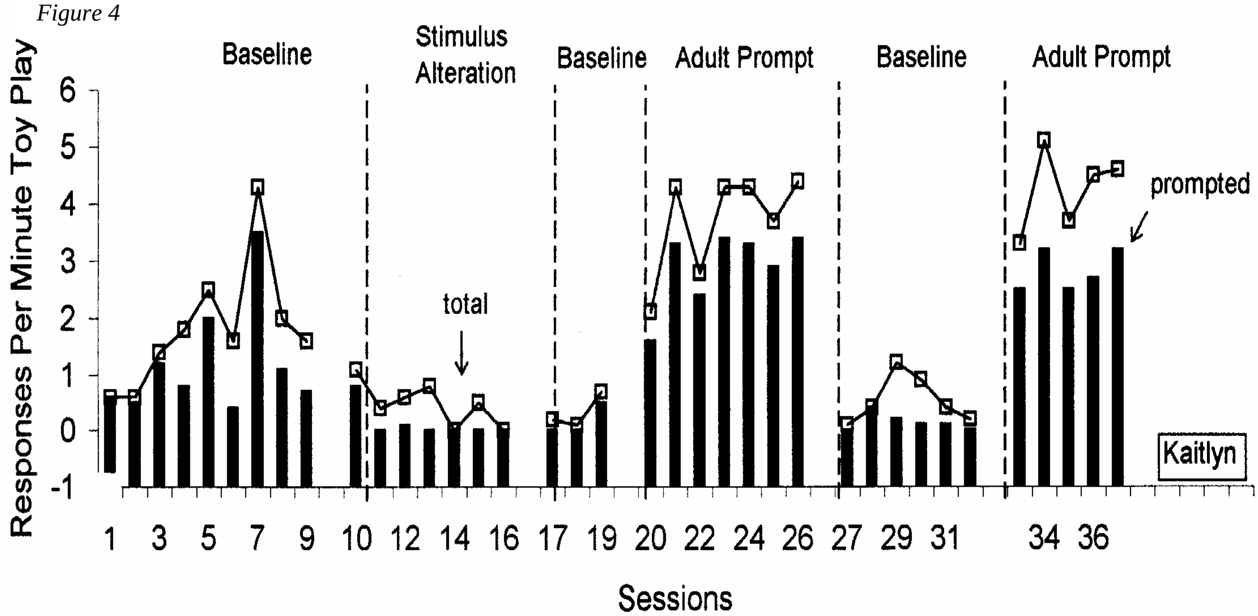


Figure 3

Greg

During baseline, Greg did not contact any of the experimental stimuli. He primarily played in the computer or manipulatives center, pressing his face against toys and repeatedly activating those toys. During the adult prompt and stimulus alteration combined phase, he exhibited variable, yet consistently higher rates (*M*=3.4 rpm) of contact with the target stimuli. During this phase, he allocated most of his play behavior to contact with the target stimuli in the target centers. During the second baseline, Greg did not contact the target stimuli. During the stimulus alteration phase, contact with the target stimuli was re-established (*M*=2.7 rpm), although this phase ended prematurely due to the end of the school year. Observations conducted behind a one-way mirror outside of experimental sessions during regular classroom activity indicated that Greg began to contact previously low-contact centers

Figure 4



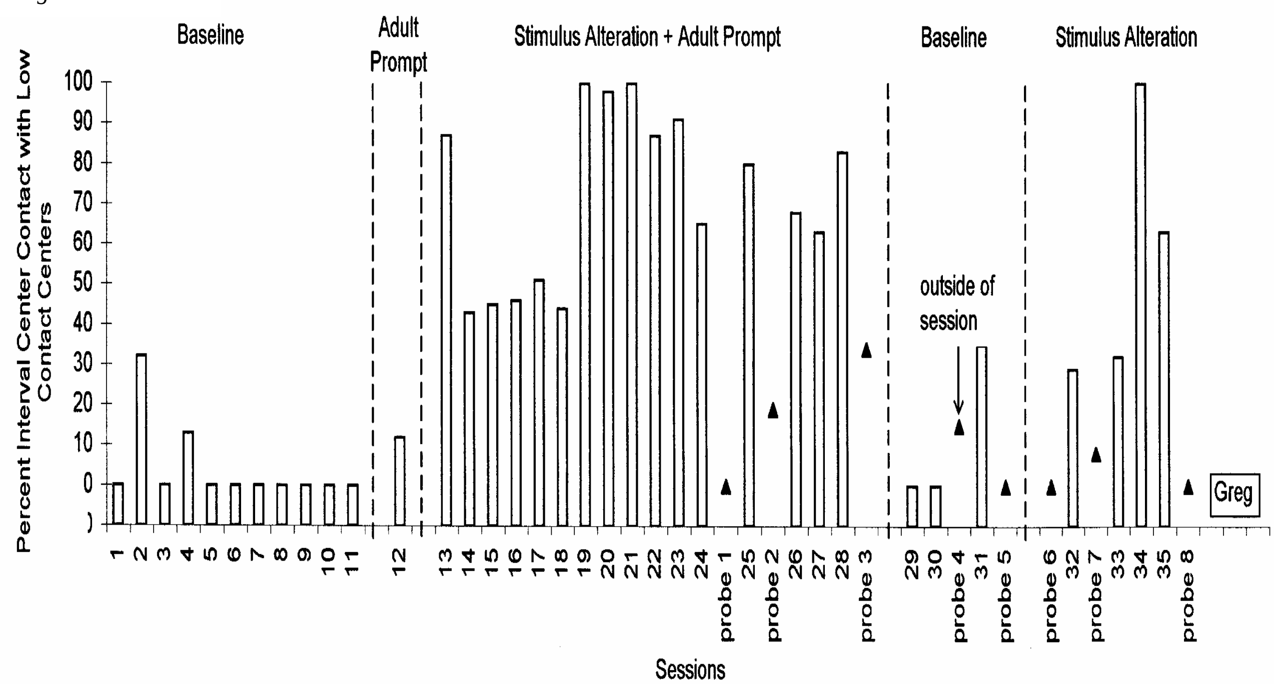
midway through the first prompting phase (see Figure 5).

DISCUSSION

The purpose of this project was to extend and apply the concept of within-stimulus prompting to toy play in an early intervention program. Toward that end, toy alterations (considered the within-stimulus prompt) and adult prompting (considered the extra-stimulus prompt) were compared for two children nominated by their teachers as exhibiting lower than desired levels of play or highly restricted play behavior. Kaitlyn was referred due to very low levels of toy play in the classroom. Adult prompting sufficiently established increased play, whereas stimulus alteration did not. Note that prompting continued to occur with Kaitlyn during the stimulus alteration phase (i.e., imperfect procedural integrity), and most of the play that occurred in this phase, as in all phases, was prompted by an adult. Greg was referred by his teacher due to highly restricted play patterns, and he tended to play only in the manipulatives and computer centers. Stimulus alteration was associated with increased contact with previously low-contact centers following a stimulus alteration with adult prompting phase and a return to baseline phase.

Within-stimulus prompts have most frequently been written about in relation to the difficulty of training children with autism to master discriminations that require simultaneous attention to multiple cues (i.e., stimulus overselectivity). Stimulus overselectivity has been identified as a potential cause of the frequent failure of newly trained skills to generalize to new settings and slightly modified task requirements (Lovaas, Schreibman, Koegel & Rhem, 1971). When responses are controlled by very circumscribed stimulus parameters, adaptation is limited. That is, establishing stimulus control for every possible stimulus condition is inefficient and in all likelihood, impossible. Thus, teaching children with autism to attend to multiple cues simultaneously is a critical goal (Schreibman & Koegel, 1982). Correct discrimination is important because an explicit link has been made between inadequate discrimination and reinforcement history, such that inadequate discrimination may lead to incorrect performance that in turn may lead to punishment or absence of reinforcement. For example, inadequate or ineffective adult directions (i.e., absence of stimulus control) may become paired with punishment, resulting in increased escape behavior (Richman & Wacker, 2001). In general few studies have attempted to isolate the variables that predict or promote complex cue discrimination. Notably, one study found that a prior reinforcement history with a component stimulus (i.e., child was trained successfully to respond correctly to one part of the more complex stimulus) resulted in overselective responding to that component when it was embedded in a multiple cue package (Huguenin, 2000). This finding suggests that

Figure 5



to enhance generalization, training should occur with multiple cues present (i.e., one aspect of a naturalistic environment), a suggestion that has been made by others both in behavior analysis (Stokes & Baer, 1977) and early intervention (Bricker & Cripe, 1992).

Although Greg's final phase was incomplete, the within-stimulus prompt successfully increased contact with centers that he previously rarely entered and contact with the experimental stimuli was similar to that obtained in the combined phase. Furthermore, disruption did not occur in the stimulus alteration phase. Thus, it is possible that toys could be altered to increase Greg's contact with low-contact items and interest centers in the classroom. One benefit of the within-stimulus prompt is that it may be a less restrictive treatment and less likely to result in disruptive behavior (as may have been the case for Greg). For Kaitlyn, adult prompting was required to establish and maintain play behaviors. This project may extend previous investigation efforts by studying the problem in a natural setting (as opposed to discrete trial format with arbitrary stimuli; Barthold & Egel, 2001) and measuring the procedural integrity with which manipulations were implemented across phases.

It is impossible to tell, however, due to the sequence of experimental phases and incomplete analysis whether or not previous pairing of the within-stimulus prompt with adult prompting may have influenced performance during the within-stimulus prompt only phase for Greg. Adult interaction was programmed to occur during both experimental conditions in order to control for the possibility that adult presence and interaction with the child influenced child responding. Recall that adult interaction was yoked across experimental phases by delivering a fixed-interval amount (equivalent to baseline average) of attention in the stimulus alteration phase and prompting in the adult prompting phase. Thus, topography and pacing (Zanolli, Daggett, & Pestine, 1995) may have affected responding. It is also impossible to determine whether or not the dependent variables changed purely as an effect of the antecedent manipulations. Contact with the planted items and centers did not occur or occurred very infrequently during baseline observations, and the alteration for Greg was sufficient to occasion initial contact. At that point, however, toy play and contact with the planted stimuli may have been trapped by the reinforcing consequences of playing with the toy.

Another limitation of this study is related to measurement of the dependent variables, particularly toy play. Innovative efforts are needed to quantify toy play for toddlers in a way that captures both fluency and accuracy of the response, and demonstrates that it is sensitive to instructional manipulation *and* predictive of important outcomes for children. Future investigations of the effectiveness of within-stimulus prompts might consider accuracy of responding rather than fluency. That is, perhaps within-stimulus prompts could be used to occasion a higher quality of toy play as opposed to increasing the amount of toy play. Future studies might also attempt to examine during baseline which, if any, stimuli or stimulus components may control the response prior to initiating training or prompting procedures (Halle & Holt, 1991; McComas, Wacker, & Cooper, 1996; McComas, Wacker, Cooper, Asmus, Richman, & Stoner, 1996). Conducting such assessment prior to implementing the within-stimulus prompt would have provided a stronger demonstration that the within-stimulus prompt was responsible for establishing stimulus control. In applied settings, the purpose of such assessment would be to ensure that the correct stimuli acquire controlling properties in making the criterion discrimination. Accomplishing this goal would allow practitioners to program for correct discrimination in the real-life settings where responding is expected to occur.

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THE ROLE OF BEHAVIOR ANALYSIS IN SCHOOL PSYCHOLOGY

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The role of behavior analysis in school psychology is ever evolving. Recently, the federal requirement of conducting functional behavioral assessments for a subgroup of children identified with disabilities has brought the need for behavior analysis to the forefront of school psychology. Presently, behavior analysis is influencing both assessment and consultation conducted in the schools. However, given the necessity for intensive training in behavior analysis and the limited training available in this area in many school psychology programs, a serious problem may be faced by the field. The future of behavior analysis within the context of school psychology is considered.

The field of school psychology is dedicated to the “science and practice of psychology with children, youth, families; learners of all ages; and the schooling process” (APA). Behavioral technology has always played a role in school psychology, but similar to other subspecialties, school psychology is a diverse field and includes professionals representing many different theoretical orientations. Thus, school psychologists who do not endorse a behavioral orientation are not required to take advantage of advances in behavioral technology. Recent changes in the Individuals with Disabilities Education Act (IDEA; Public Law 105-17, 1997), however, may catapult more school psychologists into the arena of behavior analysis. Specifically, IDEA now requires a functional behavioral assessment (FBA) to be conducted for a child with an identified disability when serious behavioral concerns have been identified that could lead to significantly reduced access to educational services (e.g., suspensions for 10 days) or changes in placement to alternative educational settings (IDEA; Public Law 105-17, 1997). For example, a FBA should be conducted if drug or weapons charges are in place so a child’s placement is changed to a more restrictive environment that is consistent with stated disciplinary policy for all children.

Given the training most practitioners have in traditional assessment procedures, the school psychologist may expect to receive requests for conducting FBAs (Shriver & Watson, 1999). Thus, although the field of behavior analysis has had the greatest impact on school psychology via behavioral consultation, the role of behavior analysis in school psychology is an evolving one. The field of school psychology is responding to both the changing needs in schools and modifications in federal law that can be best met through the application of behavior analytic principles and methods. In order to better understand the relevance of behavior analysis in school psychology, a brief discussion of behavioral assessment and behavioral consultation, as well as the future impact of behavior analysis on the field of school psychology follows.

Behavioral Assessment

FBAs have become a more common practice in the schools because federal law now requires FBAs to be conducted when a change in placement is being considered for a child with an identified disability when significant behavioral problems are interfering with obtaining educational services in a child’s present placement. Regrettably, FBA has not been specifically defined in IDEA, thus school psychologists and other behavioral specialists can choose between a range of procedures that fall under the umbrella of FBA. For example, descriptive procedures such as interviews, rating scales, or direct observation as well as experimental procedures such as brief, extended (i.e., a la Iwata, 1982), or hypothesis-driven functional analysis may be employed in order to meet the legal requirement of conducting an FBA. However, it is noteworthy that the federal government has sanctioned a specific behavioral technology for use in the schools (Telzrow, 1999).

This recent change clearly increases the value of training and expertise in behavior analysis for school psychologists because failure to conduct, interpret, and assist in the implementation of interventions based on FBAs will necessarily diminish their role in the schools. Unfortunately, limitations in training may reduce the extent to which many school psychologists can conduct proper FBAs. Few school psychology programs have identified behavior analysis to be the foundation of their training. The extent to which traditional or nonbehavioral school psychology programs can provide adequate training for their students so that they can become effective FBA specialists in the schools is questionable (Shriver & Watson, 1999). The increasing relevance and application of FBA in the field of school psychology is perhaps most clear based on the proliferation of data-based and review articles covering the topic in school psychology journals. Articles regarding FBA are regularly covered in the major school psychology journals. In fact, one school psychology journal, *School Psychology Review*, dedicated an entire issue to the topic last year (see *School Psychology Review, 2001, Volume 30*).

Many school psychologists predominantly engage in traditional psychometric assessment activities such as the administration and interpretation of intelligence and achievement tests (Bahr, 1996). In addition to these standardized tests, school psychologists are now recognizing the advantages of participating in a pre-referral intervention process designed to address the needs of children within the context of the general education classroom (Kampwirth, 1999). Application of behavioral assessment procedures can be critical in providing relevant information to these pre-referral intervention teams both in terms of behavioral and academic problems. For example, in order to determine if a referred child's 'disruptive' behavior occurs at a significantly greater rate than that demonstrated by a same-age, same-gender peer, direct observation within the classroom may be beneficial. In another case, curriculum-based assessment and/or measurement may be necessary to assess if a skill versus a performance deficit exists or to determine if a child's academic performance is significantly different from that of other children in the school district. Clearly, this information is crucial in making subsequent decisions about whether or not a child needs an intervention to be implemented or for identifying the type of intervention that is most appropriate. Application of behavior analysis in school settings through the pre-referral intervention process can yield systematic improvements in service delivery and school psychologists should be in an ideal situation for contributing to the pre-referral intervention teams in this way.

Unfortunately, barriers to the utilization of behavior analysis by school psychologists exist. For example, the test-and-place model of school psychology service delivery in which psychologists administer and interpret standardized tests in order to determine eligibility for special education services continues to pervade school settings (Reschly & Wilson, 1995). Thus, school psychologists may not be invited to participate in pre-referral intervention teams despite the fact they can play a crucial part in data collection and analysis. Pre-referral intervention teams may not recognize the contributions the school psychologist can make to their team because historically school psychologists have been pigeonholed into the role of 'tester.' Further, some school psychologists may be able to contribute ideas about therapeutic behavior techniques that could be employed but may not be able to use a behavior analytic approach to assessment and intervention due to limitations in their training (Shriver & Watson, 1999). Without sufficient training in behavior analysis, school psychologists may be able to do little more than take a cookbook approach to intervention development and implementation. This would obviously restrict their contribution to pre-referral intervention teams.

Consultation

A parallel relationship exists between the stages of behavioral consultation and the process of conducting a FBA in conjunction with implementation of a treatment on the basis of this assessment (Wilczynski, Mandal, & Fusilier, 2000). Behavioral consultation was developed in response to the need for an indirect service delivery methodology for behavior analysts and behavior therapists (Noell & Witt, 1998). School psychologists have recognized that FBAs can and should be reasonably employed within the consultation framework (Schill, Kratochwill, & Elliot, 1998). Historically, behavioral consultation relied predominantly on descriptive procedures for understanding the function of target behavior. Recently, direct behavioral consultation, a model in which the school psychologist plays a more active role (e.g., modeling the use of behavioral technology) and places a greater emphasis on experimental functional analysis procedures, has been forwarded as an alternative to traditional behavioral consultation.

Although consultation represents a role school psychologists play within school systems, consultation is an activity that is underutilized by most school psychologists (Reschley & Wilson, 1995). Most school psychologists have reportedly received some level of support from administrators, teachers, and school systems for engaging in consultation activities. Yet, many barriers to the provision of consultation services in the schools continue to occur. Most school psychologists are not given adequate time to engage in consultation, and instead are expected to complete a great number of psychometric assessments. Although most school psychologists believe they have received adequate training to provide consultation services (Wilczynski, Mandal, & Fusilier, 2000), the extent to which they have an adequate foundation in behavior analysis is questionable (Shriver and Watson, 1999).

In addition to alternate job requirements and limitations in training, Martens, Witt, Daly, and Vollmer (1999) have outlined additional barriers to the application of behavior analytic procedures through the consultation process that appear related to beliefs held by school psychologists or other school-based professionals. For example, the school consultation literature has overemphasized the importance of collaboration to the extent that maintaining a balance in power and contribution between the psychologist and teacher seems to be more valued than the integrity with which assessment and intervention procedures are implemented. To support this perspective, teachers often do not receive disciplinary action for failure to participate in assessment or intervention data collection, data analysis, or treatment implementation. Similarly, great import has been placed on a myriad of hypothetical constructs (e.g., treatment acceptability, teacher resistance, etc.) within the school-based consultation literature that are believed to be relevant to long-term success but have not been supported through empirical investigation. School psychologists concerned with the use of behavior analytic technology within the context of a consultation relationship should instead focus on the conditions under which treatment implementation with high levels of integrity occurs. Another barrier to the application of behavior analysis in school settings is the belief held by many school-based professionals that data collection is too cumbersome (i.e., requires too much time, is too difficult to collect, etc.). Although behavior analysis clearly requires sustained data collection from baseline through intervention, many more manageable data collection procedures such as permanent products and probes can be used (Martens et al., 1999).

FUTURE ROLE OF BEHAVIOR ANALYSIS IN SCHOOL PSYCHOLOGY

Although behavior analysis plays a critical role in the practice of school psychology and most programs establish at least a foundation of behavior technology in their coursework, few training programs in school psychology are self-described as behavior analytic. Currently, seven school psychology programs clearly have behavior analysis at the foundation of their training. Specifically, Hofstra University (Combined Clinical/School), Lehigh University, Louisiana State University, Mississippi State University, University of Southern Mississippi, University of California – Riverside, and Western Michigan University. Many other programs offer significant coursework in behavior analysis, but do not explicitly adopt behavior analysis as the underlying foundation of the program. Obviously, it is not necessary for all school psychology to have a strong behavioral foundation in order for the discipline to move forward. However, there must be leaders in behavior analysis in some school psychology programs so that the field of school psychology does not become divorced to far removed from mainstream behavior analysis. In the absence of strong behavior analytic programs, school psychology, as a discipline, may become uninformed about current technology that should be employed in the field.

The future of behavior analysis in school psychology is somewhat difficult to predict. It seems likely that programs will increasingly emphasize behavior analysis because of changes in the parameters of employment for school-based practitioners that have occurred in recent years (e.g., increased use of pre-referral intervention teams, need for FBAs). School psychologists must receive adequate training in order to perform behavioral assessment and consultation activities with integrity within the context of pre-referral intervention teams, one-on-one consultation, or for the determination of placement changes for children with disabilities. Adequate training must begin in graduate coursework available to both graduate students and professionals in surrounding communities.

It seems improbable weekend workshops will yield school-based practitioners who are proficient in conducting functional analyses. Even paper-and-pencil methods for hypothesizing the function of target behavior require a foundation in behavior analysis and psychologists in the schools who lack this foundation are not likely to get the strong background in behavior analysis that is necessary to adequately interpret results of questionnaires and rating scales designed to identify the function of problem behavior. This may particularly be the case when idiosyncratic variables are involved. In addition, curriculum-based measurement procedures are not included in many school psychology training programs. In order to meet the changing role of the school psychologist, training programs must provide the groundwork through coursework in single-case design methodology, applied behavior analysis, and application of these didactic experiences through practicum.

Here the field of school psychology may face a problem that continues to feed itself: Identifying professionals who are qualified to teach these courses may prove problematic for many programs that traditionally prepare students to conduct norm-referenced assessments. Thus, although the number of programs interested in increasing coursework in applied behavior analysis may be on the rise, identifying educators sufficiently prepared to offer such coursework may prove difficult. The result could be disastrous if the quality of behavior analysis training is significantly compromised. Meeting this tremendous training need will require significant and systematic planning by school psychology programs that have not historically adopted a behavior analytic orientation. Even though five years have passed since the introduction of functional behavioral assessment into federal law, this represents a relatively small span of time for major changes to occur in training programs. Certainly, any subspecialty in psychology suddenly required to prepare current students and existing practitioners to become proficient in a new technology would face similar difficulties in quickly meeting the demand. The ability of school psychology training programs to provide sufficient training to trainees and practitioners is, as yet, unknown.

There are additional ways in which behavior analysis has influenced the field of school psychology. For example, systematic examination of variables relevant to program evaluation are very clearly influenced by behavior analysis. However, as program evaluation has played a minor part in the field of school psychology, to date, a thorough review of the overlapping domains of behavior analysis, school psychology, and program evaluation will not be presented in this article. Additional details about the relationship between the areas of psychology can be found in Ervin & Ehrhardt (2000).

Behavior analysis has clearly influenced school psychology with respect to research of many leading scholars in the field (Ervin & Ehrhardt, 2000). A group of researchers in the field of school psychology regularly publish research utilizing single-case design. Single-case design methodology nicely matches the need for practitioners to provide individual services for children in the schools while the use of these methods in establishing the effectiveness of pre-referral intervention services, functional behavioral assessment, and consultation services in meeting children's needs is of utmost importance. As noted previously, many scholars in the field of school psychology do not have considerable training in single-case design methods, thus limiting the amount of research conducted using behavior analytic methods.

To summarize, the role of the school psychologist appears primed for change despite the fact many school professionals continue to hold to the view that school psychologists are the 'gatekeepers' for special education because of their historic position as psychometricians. This changing role is dependent on school psychologists' training and the utilization of behavior analytic technology. However, the extent to which school psychologists will be able to expand their role may be limited due to lack of training or unavailability of quality training in the area of applied behavior analysis.

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BEHAVIORAL FACTORS IN ASTHMA

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Asthma is a chronic airway disorder of increasing interest to behavioral psychologists in past decades. Despite treatment advances, increases in asthma morbidity and mortality, particularly among Hispanic and African American persons, continue to be a major public health concern. Several behavioral factors have been identified as having an impact on the development, presentation, management, and treatment of asthma. Our review summarizes the state of knowledge in several of these areas, including social-operant processes, treatment adherence, environmental control, symptom perception, self-monitoring, physician behavior, and the effects of comorbid psychopathology. We also discuss cultural and other contextual factors that may influence asthma-related outcomes.

Asthma is a chronic airway disorder that affects over 15 million people in the United States alone. The major characteristics of asthma include airflow obstruction, bronchial hyperresponsivity, and airway inflammation. Despite continuing advances in the understanding of asthma pathophysiology and the development of new and better treatments, the prevalence, morbidity and mortality from asthma have risen steadily in industrialized countries over the past decades. In the United States, the prevalence rate for self-reported asthma increased nearly 60% between 1982 and 1996 and 123% between 1982 and 1996 for persons aged 18-44 years (Centers for Disease Control and Prevention (CDCP), 1992; 1995; 1998). Age-adjusted rates of death by asthma have more than doubled over the past 25 years, to over 5,000 per year (CDCP, 1998; Kussin & Fulkerson, 1995). Numerous factors have been proposed to explain increases in asthma, including worsening air quality, changes in diet, allergen exposure, immunizations, decreased exposure to childhood diseases, and other lifestyle changes such as increased sedentary indoor activities.

In addition to the increased prevalence of asthma over the last quarter century, treatment outcomes for asthma continue to fall short of nationally established guidelines. For example, over 2 million emergency room visits and over 500,000 hospitalizations are made in the United States every year for asthma problems (CDC, 1998). Recent national surveys of adults and parents of children with asthma estimate that over 25% of persons with asthma made three or more unscheduled visits to their doctor, went to the emergency room, or were hospitalized for their asthma during the year (American Lung Association, 1998; Glaxo Wellcome, 1998). The National Heart, Lung, and Blood Institute (NHLBI) Expert Panel guidelines (National Heart Lung and Blood Institute, 1997) list having minimal or no need for urgent care visits or hospitalization as a goal for asthma management. Furthermore, while another NHLBI panel goal is for persons with asthma to be able to maintain normal activities levels, about one-third of asthma patients report limitations in lifestyle and daily activities from their asthma (American Lung Association, 1998; Glaxo Wellcome, 1998).

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It is likely that many factors are responsible for the divergence between desired and actual outcomes in asthma. Behavioral issues, including lack of treatment adherence by patients, physician failure to adhere to treatment guidelines, and poor doctor-patient communication skills, have been shown to contribute to the current state. We will review these and other behavioral factors that affect the development, presentation, management, and treatment of asthma.

Pavlovian Conditioning

As early as Sherrington's classic experiments (1900), changes in respiratory activity elicited by the conditional pairing of stimuli with agents that produce respiratory effects have recently been the focus of an increasing number of studies (see Ley, 1999, for an excellent review). However, a growing body of research suggests that Pavlovian conditioning could play a role in asthma symptoms. In a series of interesting studies, Van den Bergh and colleagues have shown that odors, as well as stimuli to other sensory modalities, can potently elicit conditioned respiratory symptoms and complaints when paired with symptom-inducing agents, such as CO_2-enriched air (van den Bergh, Kempynck, van de Woestijne, Baeyens, & Eelen, 1995; Van den Bergh, Stegen, & Van de Woestijne, 1997). Their typical experimental design involves the pairing of neutral or noxious odors with room or CO_2-enriched air to produce hypercapnic-like responses (i.e., behaviors similar to those produced by high CO_2 levels, e.g., increased respiration rate) to subsequent odor presentations. Later studies have extended these findings by demonstrating conditioned respiratory responses to fear-relevant images (Stegen, De Bruyne, Rasschaert, Van de Woestijne, & Van den Bergh, 1999) and showing generalization of odor-conditioned responses to new odors (Devriese et al., 2000). Others have also demonstrated conditioned changes in respiratory function. Miller and Kotses (1995) presented subjects with two different colors, one of which was paired with a stressful arithmetic task. Subsequent presentation of the color that had been paired with the stressful task elicited significant increases in respiratory resistance in participants.

Taken together, these studies show that respiratory physiology and respiratory symptoms can be conditioned in persons without asthma. To our knowledge, there have been no published reports of experimentally conditioned respiratory responses in patients with asthma. An interesting direction for future research would be to compare persons with and without asthma in conditioning paradigms to explore if those with asthma might be more susceptible to conditioning effects. If so, conditioning and counterconditioning may be underappreciated potential mechanisms and treatment approaches, respectively, in our understanding of asthma.

Social and Operant Factors

Negative effects of the social environment. Genetic predisposition is probably a necessary but insufficient precondition to the development of asthma: not all persons who are genetically predisposed develop asthma. Family stress seems to be implicated in its expression in childhood. For example, among a cohort of 150 children identified prenatally at genetic risk for asthma, parenting difficulties at three weeks of age predicted asthma onset by age 3 (Mrazek, Klinnert, Mrazek, & Macey, 1991). In addition, children with asthma are criticized more by their mothers than healthy children (Hermanns, Florin, Dietrich, Rieger, & Hahlweg, 1989; Wamboldt, Wamboldt, Gavin, Roesler, & Brugman, 1995). A proportion of adults with asthma demonstrate asthma exacerbations associated with stress or strong emotions in laboratory-based experimental paradigms (see Lehrer, 1998; Lehrer, Isenberg, & Hochron, 1993, for reviews) and in prospective daily data collection in the natural environment (e.g., Schmaling, McKnight, & Afari, in press).

These data suggest that the social environment plays an important role in the initial expression of asthma in childhood, and its course and maintenance. Classical conditioning may be implicated in the association of family stress with initial asthma expression. Possible behavioral mechanisms underlying the association of asthma course and maintenance with the social environment include inadvertent positive and/or negative reinforcement for asthma symptoms (e.g., through solicitous behaviors by others), and punishment of well behaviors and/or appropriate use of asthma medications. However, conditioning has received little research attention as a potentiating or maintenance mechanism for asthma. It is likely that environmental consequences shape symptom expression and self-management behavior (e.g., medication use), thereby exerting effects on overall asthma course. For example, catastrophic interpretations of symptoms have been related to less optimal disease management (Carr, Lehrer, & Hochron, 1995). Similarly, emotional arousal has been associated with perceived but not objectively demonstrated airway obstruction (Rietveld, van Beest, & Everaerd, 1999). One study examined the moderating effects of relationship satisfaction on reactions to asthma (Giardino, Schmaling, & Afari, in press). This study found that among persons in satisfied intimate relationships, catastrophic cognitions were associated with asthma symptoms related to emotional reactions such as fear, irritability, anger, and loneliness. However among persons in unsupportive intimate relationships, catastrophic cognitions were associated with asthma symptoms related to physical reactions such as shortness of breath, congestion, and rapid breathing. These results suggest that a kindling effect may come about with asthma symptoms occurring in the context of unsupportive relationships: if emotional support is not provided during asthma exacerbation, then interoceptive cueing by a selective focus on respiratory sensations may exacerbate further the perception of respiratory difficulties. While the function of unsupportive social consequences can only be determined be observing its effects on subsequent occurrences of symptom expression, the associational studies performed to date provide support for the reinforcing potency of the social environment.

Positive effects of the social environment. Social relationships can be a source of stress with deleterious effects on asthma as noted above, or can decrease or buffer the effects of stress on illness. Asthma patients with high relationship assets required less medication to manage their asthma than those who were low in relationship assets (de Araujo, Van Arsdel, Holmes, & Dudley, 1973). More intimate relationship satisfaction was associated with more medication use, after accounting for the effects of disease severity, suggesting that patients in more satisfied relationships may be more treatment adherent (Schmaling, Afari, Barnhart, & Buchwald, 1997). Patients in relationships were 1.5 times more likely to evidence satisfactory adherence with their medications than single patients (Rand, Nides, Cowles, Wise, & Connett, 1995). Significant others may help cue the patient to use their medications through overt prompts or by serving as a discriminative stimulus.

Medication Adherence

The lack of adherence, that is not using medications as prescribed, is thought to explain significant proportions of morbidity, mortality, and urgent/emergent health care utilization. It has been estimated that patients take about half of prescribed medications for asthma (Bender, Milgrom, & Rand, 1997). There are two major classes of asthma medications, commonly known as reliever and controller medications. According to current treatment guidelines (National Heart Lung and Blood Institute, 1997), controller medications *should be* prescribed for use on a regular basis by patients with moderate- or severe-persistent asthma, and *may be* prescribed for use by patients with mild persistent asthma, for their prophylactic anti-inflammatory effects. Reliever medications are used on an as-needed basis to reverse acute airway constriction. Patient adherence with reliever medications is better than with controller medications (e.g., Kelloway, Wyatt, DeMarco, & Adlis, 2000). There are a number of reasons for greater use of reliever medications -- their fast-acting effects are more reinforcing (a felt diminution of the discomfort of wheezing, coughing, shortness or breath and other asthma symptoms following medication use) than the effects of controller medications for which no immediate benefits are felt, but may be associated with unpleasant taste and other side-effects.

Adherence with medications is only one component of treatment adherence. There are other important components of treatment adherence, such as allergen avoidance and environmental control (e.g., regular cleaning and washing to decrease dust mite exposure). Similar to the use of controller medications, such preventive efforts are not associated with strong and immediate consequences, so the potency of reinforcers associated with patient adherence with these practices may be relatively small.

Environmental Factors

A number of environmental factors have been linked to asthma onset and course. The influence of these factors may be partially explained through conditioning mechanisms, although this possibility is speculative as the research regarding the effects of these environmental factors is descriptive rather than informed by behavioral perspectives.

Diet. Several dietary factors, particularly during childhood and adolescence, have been associated with increased risk for asthma (Fogarty & Britton, 2000). Introduction of cow's milk before the age of 3 months is a significant risk factor for developing asthma and allergy (Gdalevich, Mimouni, & Mimouni, 2001). This effect may be due to exposure to allergens in the cow's milk or the absence of immunomodulatory benefits of breast milk. Among adolescents, a diet high in saturated fats and low in vitamin C is also associated with increased risk for asthma (Huang & Pan, 2001).

High dietary sodium intake has been identified as a risk factor for the development of asthma. Early epidemiological studies identified a positive association between dietary sodium levels in certain geographic populations and increased risk for asthma. Later studies demonstrated higher bronchial reactivity in asthma patients with higher plasma sodium levels. More recently researchers (Gotshall, Mickleborough, & Cordain, 2000; Mickleborough, Gotshall, Cordain, & Lindley, 2001) experimentally altered dietary sodium intake in participants with exercise-induced asthma and found that decreased salt intake improved, and increased salt intake decreased, pulmonary function during exercise testing.

Smoking. Several studies have demonstrated the adverse effects of exposure to tobacco smoke on asthma (Strachan & Cook, 1998). Maternal smoking and other environmental exposures to tobacco smoke appear to be a significant risk factor for the development of asthma in children. Exposure to smoking in patients with established asthma is associated with more frequent and severe symptoms, poorer lung function (Gilliland, Li, & Peters, 2001; Li et al., 2000), decreased quality of life, and higher utilization of health care services (Sippel, Pedula, Vollmer, Buist, & Osborne, 1999). Interestingly exposure to smoking may have a different association with health care utilization for children and adults. In adults with asthma, active or passive exposure to tobacco smoke is directly associated with increased use of health care services, particularly urgent care services. In contrast, children whose parents frequently smoke in their presence are, independent of socio-economic factors, less likely to be brought to the doctor for treatment of their asthma (Crombie, Wright, Irvine, Clark, & Slane, 2001). Thus, smoking may be associated with a double harm in children: the deleterious effects of exposure to smoke, and parents who are less likely to provide them with necessary medical care.

Exposure to other allergens. Exposure and sensitivity to indoor allergens, such as dust mite, cat, dog, and cockroach, have often, but inconsistently, been associated with the development or exacerbation of asthma (e.g., Nelson et al., 1999; Peat, Tovey, Mellis, Leeder, & Woolcock, 1993). The relationship between early allergen exposure, atopy (i.e., hypersensitivity to environmental allergens), and asthma, remain unclear. A recent large cohort study (Lau et al., 2000) found that exposure to dust-mite and cat allergens in early childhood was associated with the development of allergic sensitization to these allergens, but not with the development of asthma. Allergic sensitization to indoor allergens *was* associated with the presence of asthma, though, leading the authors to conclude that persons with asthma may be more susceptible to becoming sensitized to environmental allergens to which they are commonly exposed. Atopic responses to indoor allergens may *then* exacerbate asthma symptoms. This study illustrates the importance of distinguishing between atopy and asthma, as the determinants of atopy are at least in part different from those for asthma.

Symptom Perception

Good self-management is crucial to optimal asthma care. Self-management skills include adherence with medications, including using reliever medications based on accurate perceptions of need. Appropriate patient responses to symptom cues are necessary for optimal asthma control.

However, patient detection of and appropriate response to changes in airflow is often suboptimal. Many studies have shown a poor correspondence between symptom reports and objective airflow (Apter, Affleck et al., 1997; Kendrick, Higgs, Whitfield, & Laszlo, 1993). A lack of correspondence between subjective and objective airflow may be attributable in part to emotional arousal (Rietveld et al., 1999). However, other studies have reported strong associations between perceived breathlessness and lung function (Burdon, Juniper, Killian, Hargreave, & Campbell, 1982).

An appropriate response to asthma symptoms, such as using medications when the need to do so is identified, is an independent step in appropriate self-management. Appropriate self-management also includes knowing the limitations to self-management and when seeking medical intervention is necessary. Not uncommonly, patients delay seeking additional medical intervention, despite their reported awareness of decreasing lung function (e.g., Molfino, Nannini, Martelli, & Slutsky, 1991). Such delays may explain in part the increase in asthma mortality observed in recent years; patient overreliance on reliever medications is among the factors believed to contribute to the increase in mortality (e.g., Sears, 1986).

The generally effective and immediately reinforcing nature of using reliever medications may contribute to delays in seeking additional medical treatment. Patients' learning histories may lead them to expect reliever medications to be efficacious, possibly diminishing their vigilance for the need of further treatment. Delays in seeking treatment also have been linked to the presence of co-occurring psychiatric disorders (Picado, Montserrat, de Pablo, Plaza, & Agusti-Vidal, 1989; Yellowlees & Ruffin, 1989), but the mechanisms underlying this association are unknown.

Self-Monitoring

Whereas data are tenuous supporting patients' ability to consistently and accurately perceive their airflow, self-monitoring devices known as peak flow meters provide more objective feedback regarding lung function. Peak flow meters are available in portable sizes (to fit in a purse or jacket pocket) and can be used to determine the need for more medication by comparing current airflow with personal airflow history and well established norms based on gender, age, and height. Intervention studies involving giving feedback to patients regarding their airflow have demonstrated that patient perceptions can be shaped to become more accurate (Harver, 1994; Stout, Kotses, & Creer, 1997). As with other chronic illness self-monitoring strategies, such as glucose monitoring in diabetes, self-monitoring of airflow is a useful self-management and treatment-guiding tool.

SOCIOCULTURAL AND ECONOMIC FACTORS

Morbidity and mortality from asthma disproportionately affects African American and Hispanic persons in the United States. Hispanic and African Americans with asthma also have more emergency room (ER) visits and hospitalization for their asthma (CDCP, 1998; Gilthorpe et al., 1998; Goodman, Stukel, & Chang, 1998; Legorreta et al., 1998; Murray, Stang, & Tierney, 1997; Ray, Thamer, Fadillioglu, & Gergen, 1998; Zoratti et al., 1998), even after controlling for health insurance coverage (Zoratti et al., 1998; but see Apter, Reisine et al., 1997). Krishnan et al. (2001) surveyed adult asthma patients within several managed care organizations and found that, even after adjusting for age, education, employment, and asthma severity, African American were less likely to receive care consistent with NHLBI treatment guidelines for medication use, self-management education, trigger avoidance, and specialist care.

There is some evidence for an interaction between race and income on asthma morbidity and use of urgent care facilities. Miller (2000) showed that, in a population-based, representative sample of children, poverty was associated with increased prevalence of asthma among white, but not black, children. For black children, rates of asthma were higher compared to whites and not significantly different between low and higher SES groups. Low SES was also associated with increased ER use among white children. But again, for black children, ER use remained higher across SES categories. Thus, unlike for white children, income and sociodemographic factors did not explain increased risk for asthma nor higher emergency room utilization, suggesting that perhaps culturally influenced behaviors are responsible for observed differences.

Differences related to communication may be one important way that culture is linked to asthma healthcare disparities among African-American and Hispanic persons with asthma. Language used to express asthma symptoms may be strongly influenced by culture. Among Hispanic patients for example, symptom expression may differ depending on their culture, class, education, and emotional stress (Ortega & Calderon, 2000). A recent study comparing African-American and Caucasian adults with asthma on the words they use to describe breathlessness found that African-American patients used different word descriptors than Caucasian participants following pharmacologically-induced bronchoconstriction (Hardie, Janson, Gold, Carrieri-Kohlman, & Boushey, 2000). Not only did groups differ on the descriptors used, e.g., *scared-agitated, tight throat, itchy throat*, from the African-American patients versus, *out of air, deep breath, lightheaded* from the Caucasian patients, but their descriptors also indicated that each group *experienced* the effects in different parts of their body. African Americans' descriptors tended to focus on symptoms in the throat, while Caucasians used words related to the lower airways and chest wall. Reasons for these differences are unknown, but it is important for physicians to be aware of these ethnic differences in verbal behavior. For example, Saha et al. (1999) report that black and Hispanic patients tend to rate their satisfaction with and quality of care better when they have racially concordant physicians. Regardless of race, reports of better care appear to have been strongly affected by patients' perceptions that their physicians listened and treated them with respect.

Physician Behavior

As suggested above, physician behavior may also have a significant impact on asthma outcomes. Recent surveys of physicians' knowledge and use of NHLBI treatment guidelines (NHLBI, 1997) indicate that despite physicians' familiarity and agreement with practice guidelines their full implementation with patients occurs infrequently. For example, Finklestein et al. (2000) reported that, among HMO primary care physicians treating children with asthma, only 21% reported using spirometry "always" or "most of the time" during their initial work-ups for patients with asthma. During routine follow-up exams this number dropped to 8.3%. In addition, only 50% of patients received written treatment plans, despite NHLBI recommendations that all patients with asthma be given a written daily self-management plan, as well as an action plan for exacerbations. A second study (Cabana, Rand, Becher, & Rubin, 2001) sought to identify barriers to the implementation of four specific guideline items: 1) instruction in daily peak flow monitoring with patients over 8 years old who have daily symptoms, 2) prescription of daily inhaled corticosteroids for patients with daily symptoms, 3) screening patients with asthma for smoking and counseling smoking cessation, and 4) screening parents of patients with asthma for smoking and counseling smoking cessation. Lack of familiarity with guidelines and lack of time were significantly associated with nonadherence to all four treatment guidelines. Also, providers' self-reported lack of self-efficacy ("confidence in the ability to perform the guideline component") was significantly associated with failure to give instruction in peak flow monitoring and screening and counseling of patients and parents for smoking.

"Active partnerships" between provider and patient through education and communication is a cornerstone of the NHLBI asthma management program. In addition to providing appropriate treatment regimens and information, communication with patients and families in a way that will optimize learning has been identified as an element of a clinician's encounter that is associated with effective patient self-management (Clark et al., 1995). Most studies also suggest that the emotional milieu between provider and patient is significantly related to patients' satisfaction with the care they receive, and also the likelihood that they will comply with recommended treatment regimens (e.g., Ben-Sira, 1980; Ben-Sira, 1982; DiMatteo, Hays, & Prince, 1986). One recent study of the effects of behavioral self-regulation training for pediatric asthma physicians found that, compared to a control group, physicians who received the training showed more guideline-adherent behaviors (Clark et al., 2000). Furthermore, patients' parents reported more positive physician communications behaviors and higher satisfaction with care. Subsequently, these patients had fewer emergency room visits and hospitalizations for asthma. Physicians in the seminar were retrained to "examine their own behaviour and to identify ways that they could develop a better partnership with their patients." Components included creating a supportive environment, reinforcing positive self-management efforts, and increasing patient self-efficacy.

Thus, as with patient education programs, behaviorally based training programs for clinicians may be an important part of comprehensive programs designed to improve asthma treatment outcomes. However, much more research is needed to better identify physician behaviors that promote increased patient adherence and health outcomes, as well as the best way to educate and train physicians to employ them.

Psychopathology in Asthma

Several studies suggest that persons with asthma are more likely to suffer from psychological problems than the general population, especially anxiety disorders such as panic disorder (Afari, Schmaling, Barnhart, & Buchwald, 2001; Brown, Khan, & Mahadi, 2000; Bussing, Burket, & Kelleher, 1996; Carr, Lehrer, Rausch, & Hochron, 1994; Perna, Bertani, Politi, Colombo, & Bellodi, 1997; Shavitt, Gentil, & Mandetta, 1992; Yellowlees, Haynes, Potts, & Ruffin, 1988). Estimates from treatment-seeking samples suggest that panic disorder is three- to ten-times more common among patients with asthma than in the general population. While these estimates may be inflated given that asthma patients with anxiety disorders may frequently utilize healthcare, most are still greater than prevalence rates taken from general primary care samples (Katon et al., 1986; Kinsman, Luparello, O'Banion, & Spector, 1973; Leon et al., 1995; Olfson et al., 2000), suggesting that there is indeed a particularly high co-occurrence of panic disorder with asthma. Also, there is evidence that panic disorder isassociated with intermittent respiratory disease (i.e., asthma), while depression is found more often in those with continuous respiratory problems, such as chronic obstructive pulmonary disease or very severe asthma (Kinsman, Fernandez, Schocket, Dirks, & Covino, 1983; Kinsman et al., 1973; Spinhoven, Ros, Westgeest, & Van der Does, 1994).

Several theories have been proposed to explain the excessive comorbidity of panic disorder with asthma. For example, asthma may instigate panic disorder by producing threatening bodily sensations (i.e., the asthma attack) to which anxiety responses may co-occur among susceptible individuals. One family study, for example, showed a high rate of panic disorder among persons with asthma who had a family history of anxiety disorders, but not among those without (Perna et al., 1997).

The link between asthma and depression may be bi-directional. There is consistent evidence that depressed mood leads to worsening pulmonary function in those with asthma (Miller & Wood, 1997; Ritz, Claussen, & Dahme, 2001; Ritz & Steptoe, 2000). There are also several reports of increased risk for clinical depression in children with severe asthma (Bennett, 1994; Bussing, Halfon, Benjamin, & Wells, 1995) and higher rates of depression in first-degree relatives of adolescents with asthma (Wamboldt, Weintraub, Krafchick, & Wamboldt, 1996). However, other evidence suggests that reports of increased depression in children with asthma may be due to higher report of internalizing behavior problems by *parents* of children with more severe asthma than from measurable differences in the children themselves. However, there is evidence that adults with asthma suffer from clinical depression at twice the rate of the general population. Furthermore, depression is associated with decreased functional status (Afari et al., 2001) and lower treatment adherence (Cluley & Cochrane, 2001) in persons with asthma. Chronic illness and depression may be associated with withdrawal from and discontinuation of positively reinforcing activities because of fatigue and other symptoms; in turn, the diminution of positive activities may further exacerbate symptoms of depression, resulting in impaired functional status (Ferster, 1973).

CONCLUSIONS AND FUTURE DIRECTIONS

A growing body of research literature suggests that behavioral factors may play an important role in the development, presentation, management, and treatment of asthma. Clinical practice guidelines for the management of asthma (NHLBI, 1997) include several areas directly related to, or strongly affected by, behavioral processes. Education of patients and patients' families, patient self-monitoring, adherence to treatment and behavior action plans, and avoidance of triggers are behaviors critical to comprehensive asthma care. In addition, we discussed how operant and Pavlovian conditioning may impact several aspects of asthma care, and how the behavior of clinical providers can be very important in determining how well patients with asthma follow treatment regimes. Socio-cultural factors may also affect treatment-seeking behavior, as well as how patients communicate asthma symptoms. Finally, we discussed the association and impact of certain psychological disorders, such as panic disorder and depression, on persons with asthma.

There is still much to be learned regarding the role of behavioral factors in asthma. Future research will need to apply rigorous experimental designs to isolate variables responsible for the associations observed between the behavior of patients, families, and providers, and asthma outcomes. More prospective studies will be required to verify proposed cause-effect relationships between these variables. Finally, we need to continue to develop, test, and implement interventions based on sound behavioral principles and direct these efforts toward enhancing preventative and therapeutic skills in those with asthma and the clinicians who treat them. Equally important will be methods designed to improve the ability of clinical providers to impact patient behavior.

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AN OVERVIEW AND RESEARCH SUMMARY OF PEER-DELIVERED CORRECTIVE READING INSTRUCTION

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The purpose of this paper is to provide an overview and research summary of peer-delivered Corrective Reading instruction. Emphasis is placed on a program entitled, Project PALS (Peer-Assisted Learning System) conducted in Washington State. It has been shown that Project PALS can improve the reading performance of high school students who have difficulty reading, including students at risk for school failure and those identified to receive special education services. Finally, areas of future research are discussed.

Educational reform is at the forefront of national debates. The public is concerned about low achieving public schools; federal and state governments are taking action to instill changes in our schools so that academic success by all children can be realized. Statewide academic testing at various grade levels is being conducted nationwide for accountability and assessment purposes. Educators continue to search for school reform models and procedures that can make a difference in the education of our youth. Behavior analysis in education is a missing voice in current school reform and policy literatures. Parents and education consumer groups need to be convinced of the utility of behavior analysis in education to education reform for EVERY learner, and beyond "special" learners. John Stone's work (see http://cpaa.asu.edu/cpaa/v4n8.html and http://www.education-consumers.com) is one good source.

There are several reasons why behavior analysts are in a prime position to have a great deal of impact on this school reform movement. First, behavior analysts routinely take the kinds of data the public and funding agencies want. Behavior analysts collect both summative and formative data. In fact, one of the attributes that distinguishes behavior analysts from others is their demand for and collection of data. Second, behavior analysts are trained to make data-based decisions. If the kinds of outcomes we expect are not being demonstrated, changes will be made. However, these changes will be made based on data rather than on testimonials or opinions. Third, behavior analysts have the technology to make meaningful changes in school settings. Effective instructional techniques stem from or are consistent with a behavioral framework. These procedures include, but are not limited to, Direct Instruction, Precision Teaching, Personalized System of Instruction, and Programmed Instruction (West & Hamerlynck, 1992) as well as Class-Wide Peer Tutoring, Strategic Instruction, and Cooperative Learning (Meese, 2001). Finally, behavior analysts have expertise in other areas of learning (e.g., functional living skills) that can be adapted to the teaching of academic skills. For example, peer-delivered instruction has a long and rich research base (Fulk & King, 2001; Lindsley & Johnson, 1997; Maheady, Sacca, & Harper, 1988; Meese, 2001). Therefore, taken together, behavior analysts are in a position to make a meaningful and significant impact in our public schools. This paper will address a serious academic problem in the U.S.; specifically, the reading deficits of our middle school and high school students will be examined. Instructional programs and techniques (i.e., Direct Instruction and peer-mediated strategies) that have been applied to this problem will be discussed. Finally, areas of future research will be presented. Project Follow-Through was the largest educational experiment in history, yet the databased results vindicating Direct Instruction and Behavior Analysis models were ignored and (allegedly) covered up. See Lindsley (1984, 1992) as well as http://darkwing.uoregon.edu/~adiep/ft/151toc.htm for further information.

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Overview of Reading Problems

Over the years whole groups of high school students have experienced learning failures, particularly in the area of reading, not necessarily because of "cognitive" deficits but because of poor instruction. They were not taught effectively in their early academic careers and continued the spiral of failure into high school (Engelmann, 1992; Hempenstall, 1999). They cannot access their general education classes and fall further and further behind—employment options become limited and students begin to feel hopeless. What options do they now have? Because these students experience repeated failures they are identified to receive special education services (typically in elementary school) with the hope that the provision of specially designed instruction--designed to meet their unique learning needs as noted in IDEA 1997--will be the ticket to improving their school performance. Interestingly, Vaughn, Moody, and Schumm (1998) examined the reading practices of elementary special education teachers and revealed a series of "broken promises"—"the most obvious is the broken promise to the student and the parent that an individualized reading program will be provided to each student to meet their specific needs" (p.222). Vaughn et al. (1998) noted the following:

Large group instruction provided by most special educators was oriented around a whole language or literature-based approach to literacy—this simply mirrored what they received in the general education classroom;

Isolated skills instruction (such as explicit phonics instruction) was observed infrequently;

Student reading achievement scores showed little to no growth as measured by the Stanford Achievement Test when the aforementioned reading instruction was provided; and

Teachers were "starving" for professional development experiences that provide them with research-based reading practices that yield effective outcomes for students with severe reading difficulties.

In a follow-up investigation, Moody, Vaughn, Hughes, and Fischer (2001) noted little change from their original findings—no significant gains in reading were evidenced by students (both comprehension and decoding fluency).

National statistics reflect the growing trend of the low reading skills of today's youth. According to the National Center for Education Statistics (1999), only 33% of students in grade 8 and 40% of students in grade 12 are able to meet or exceed the reading skill requirements at the proficient level. Performance at the proficient level is "identified by the NAGB as the level that all students should reach" (p. 21). (The NAGB is an acronym for the National Assessment Governing Board.) Thus, 67% of students in grade 8 and 60% of students in grade 12 are below the proficiency level of reading skills and need remediation. This percentage of students is indeed quite alarming.

It seems that almost every classroom teacher in America has encountered students who cannot or do not read. In fact, reading has been cited as the principal cause of failure in school (Carnine, Silbert, & Kameenui, 1997). Further, when students qualify for special education services, reading is the number one area of difficulty (Meese, 2001). Smith, Polloway, Patton, and Dowdy (1998) note that about 80% of students identified as having a learning disability had primary deficits in reading and related language functions. Further, Smith et al. (1998) and Lewis and Doorlag (1999) report that problems are often found in basic reading skills and reading comprehension. These students often struggle with oral reading tasks. This oral reading component may cause a tremendous amount of embarrassment to these students who already lack confidence in their own skills Additionally, some children with disabilities such as learning disabilities may be able to "word call" correctly but not remember what they have read. Comprehension problems may include one or more of the following: identifying the main idea, recalling facts and events in a sequence, and making inferences or evaluating what has been read (Mercer, 1997, as cited in Smith et al., 1998).

Academic deficits such a poor reading skills often lead to maladaptive behavior and decreased motivation to participate in school tasks and activities (Scott, Nelson, & Liaupsin, 2001; Wasson, Beare, & Wasson, 1990). The long-term implications of poor reading skills are also troublesome. For example, children with reading deficits often experience school failure and dropout, emotional disturbance, delinquency, drug and alcohol use, gang membership, adult criminality, and/or, serious violent acts (Cicchetti & Nurcombe, 1993). "Inadequate reading skill can eventually interfere significantly with an individual's capacity for economic independence and with his or her general knowledge of the world" (Bartel, 1990, p. 97).

It becomes increasingly difficult for students to be successful in content areas if their reading problems are not remediated (Bartel, 1990). Kameenui and Carnine (1998) state that large vocabulary differences exist between diverse learners and average achievers in terms of the number of words known and depth of word knowledge in content area classes; further, these differences are apparent early and increase over time. Thus, for the adolescent with a learning disability, this lack of skill development compounded oftentimes with low reading performance makes accessing the general education curriculum particularly problematic. Kameenui and Carnine note that we must go beyond simply teaching vocabulary words one-by-one (this would take an instructional lifetime to acquire since there are too many words and too little time for instruction). We must provide learners with structured reading opportunities that teach students strategies for learning new words and concepts from context.

One possible reason for the lack of acceptable academic performance by students is that many teachers do not have specific training in teaching reading skills at the middle school or high school levels. They also do not have the time to provide one-on-one instruction to the vast number of students who need assistance. Another reason may be the fact that these students are not given enough opportunities to engage in academic behaviors actively (Ezell, Kohler, & Strain, 1994; Simmons, Fuchs, Fuchs, Mathes, & Hodge, 1995). Further, if reading is taught, students typically do not focus on building fluency (reading with speed and accuracy). Sprick and Howard (1995-1997) noted that "although fluency alone is not sufficient for reading with understanding, it is clear that it is a necessary prerequisite for understanding, interpreting, and responding to print" (p. 25). Innovative approaches to academic instruction are needed which focus on doing more in less time (given the severity of the deficits), incorporate a fluency piece coupled with Direct Instruction in reading, and provide a framework to succeed and be successful, thereby helping students to achieve in school.

Special Education

The Office of Special Education Programs (OSEP) (1999), in their "Ideas that Work" document that focuses on five strategic directions to help students with disabilities succeed in school, cited the need to improve appropriate access to the general education curriculum. In order to realize this strategic direction, schools may need to extend effective interventions targeted for young students with reading difficulties to older students so that this "equal access to the general education curriculum" can be achieved. Traditionally, secondary special education teachers focused on "reading to learn" or comprehension strategies to maximize the integration of students into content area classes. The assumption was made that these students could read—they simply did not "understand" their more difficult texts in content area classes. "Learning to read" or decoding strategies were typically tackled by elementary special education teachers. Now, secondary special education teachers are grappling with the notion that they must go back to square one and teach these students "reading to learn" and "learning to read" strategies so that students can access their general education classes in a more effective manner. "Intensive specific interventions that differ considerably from what can be provided in large, whole group reading activities" are needed for these students to improve their reading skills (Torgesen, Wagner, Rashotte, Alexander, & Conway, 1997). Where do secondary special education teachers turn for this assistance? What innovative and intensive intervention could be provided to improve the fulcrum reading skills of these students and provide sufficient motivation for them to realize their full potential?

Direct Instruction

Direct Instruction (DI) follows the creed, "if the student has not learned, the teacher has not taught" (Adams & Engelmann, 1996). DI involves a set of techniques and sequences developed by Siegfried Engelmann and his colleagues as well as a commercially available programs published through Science Research Associates (SRA) that incorporate these specified techniques and sequences (Adams & Engelmann). Teaching techniques and sequences typically focus on doing more in less time and structure learning around the effective teaching cycle. New information is presented via teacher modeling, students practice what they have learned through guided practice (involving feedback), and students are tested on what they know through independent practice activities. Reinforcement and effective error correction procedures are integral to the program as well as carefully sequenced examples. Evaluation is a key component of the program not only through observation of unison responses of students but also through individual mastery tests and other evaluative activities (e.g., workbooks, takehomes). Flexible skill grouping is utilized. DI programs are scripted to free teachers from developing curricula, "reinventing the wheel of instruction," so teachers can focus more on student performance and extension activities. Scripts also provide a basis for teachers to achieve effects similar to those achieved during field testing.

Overview of the Corrective Reading Program. One effective approach to remediate reading deficits of middle school and high school students involves the use of the DI program entitled, Corrective Reading (Engelmann, Hanner, & Johnson, 1999). The Corrective Reading program (CRP) is designed to help students in grades 3 through 12 who have deficits in decoding and/or comprehension. A placement test is provided to students to ensure their success in the program. There are two strands of the CRP-Decoding and Comprehension-and four levels-A, B1, B2, and C.

The Decoding programs are designed for students who make frequent word identification errors which may hinder their skill in understanding what they are reading; their reading rate is slow which hinders their skill in recalling specific details of a passage; they are not highly motivated, having experienced frequent failure when attempting to read material (Engelmann et al., 1999). The Comprehension programs are designed for students who do not follow instructions precisely, lack analytical skills, have poor memory for information, are deficient in vocabulary, and are not highly motivated when it comes to reading or answering questions about what they have read (Engelmann et al., 1999).

Effectiveness of the Corrective Reading Program

Students from a wide variety of backgrounds and levels of intelligence have exhibited improved reading performance after completing the CRP (Coulter, 1997; Grossen, 1999). Grossen (1999) completed an exhaustive review of the CRP research and summarized investigations involving its use with general education students, students with limited English, and special education populations. Overall, the CRP was compared to many instructional methods in various settings (Carnine et al., 1997) and was found to be effective. For example, Gregory, Hackney, and Gregory (1982) compared two groups of 6th graders with low reading skills and found that the Corrective Reading group made higher gains than the comparison group in both decoding and comprehension. Kasendorf and McQuaid (1987) found that students participating in Corrective Reading, who had tested in the bottom quartile in reading, made higher gains than the norm for a typical school year. When analyzing these studies, Grossen (1999) noted, "in most cases the rate of learning exceeded the normal rate, thus allowing students eventually to catch up with their peers" (p. 23).

Peer-Delivered Instruction

The use of peers to deliver instruction is an effective, efficient teaching strategy (Grigal, 1998). Peer-delivered instruction refers to an alternative teaching arrangement in which students serve as instructional agents for their classmates (Maheady, 1990; Maheady, Sacca, & Harper, 1987; Maheady et al., 1988). Advantages to peer-delivered instruction include: (a) the creation of a more favorable student/teacher ratio, (b) increased time that students are on task, (c) more opportunities for students to respond, (d) enhanced student motivation, (e) enhanced interpersonal relationships, (f) increased opportunities for immediate error correction, and (g) increased opportunities for students to receive individualized help and encouragement (Wolery, Bailey, & Sugai, 1988).

Peer-delivered instruction offers an alternative approach to meeting students' needs. Students work side-by-side, learning new skills and exploring avenues not previously traveled. They learn through a peer who may be dealing with similar life and school issues. Not only are academic skills gained but social skills as well (Greenwood, Carta, & Hall, 1988). An added benefit of using peer instructors is that it offers an economically feasible method of delivering services in a time of diminishing resources.

Effectiveness of peer-delivered instruction

Empirical evidence supports the use of peers as instructional agents in teaching academic skills to students (e.g., Fulk & King, 2001; Lindsley & Johnson, 1997; Lindstrom, Benz, & Johnson, 1996; Simmons et al., 1995). For example, Simmons et al. (1995) investigated the effects of explicit teaching (systematizing instruction with presentation, guided practice, and independent practice) and peer instruction on the reading achievement of students with learning disabilities and low-performing readers. Teachers were randomly assigned to one of two conditions (explicit teaching or explicit teaching and peer tutoring). Results showed a significant effect when explicit teaching was combined with peer tutoring. However, explicit teaching alone did not show differences. Similarly, Cushing and Kennedy (1997) demonstrated that academic engagement (e.g., attending during activities and engaging in assignments) increased when peers without disabilities worked with students with disabilities. Madrid, Terry, Greenwood, Whaley, and Webber (1998) used peer-delivered instruction to teach spelling to at-risk students. Three conditions were compared in an alternating treatments design (i.e., active peer-tutoring, passive peer tutoring, and teacher-mediated instruction). Results showed that both of the peer tutoring models improved spelling posttest scores more than the teacher-mediated condition; the two tutoring conditions were not significantly different from one another. Studies such as these show that using peers as instructors is an effective and efficient means by which to deliver instruction. Often, peer instruction is more effective than typical teacher-classroom interactions (Greenwood, Dinwiddie, & Terry, 1984).

Project PALS

Over the past 5 years we have piloted a program-Project PALS (Peer Assisted Learning System)-that combines the CRP with peer-delivered instruction in local high schools who have partnered with Eastern Washington University (Marchand-Martella, Martella, & Waldron-Soler, 2000). Through this partnership, we train high school juniors and seniors to use the CRP, provide these students with college credits through an established state-approved program called Running Start, and pair them with learners who are reading at least two or more grade levels below their expected level. This program is currently in place in nine high schools in and around Spokane, Washington, one high school in central Washington, and six high schools in the Tacoma/Seattle area. More than 500 peer instructors and over 1000 students in need of reading assistance have participated. Most of the participating learners are those considered at risk for school failure who do not qualify for special education services; these students have fallen through the cracks, often not receiving reading instruction since elementary school. Thus, their skills have further atrophied and their enthusiasm about school and reading has waned.

Effectiveness of Project PALS

To date, four studies have been published on Project PALS. First, Marchand-Martella, Martella, Bettis, and Blakely (in press) assessed implementation aspects of Project PALS in six area high schools. Specifically, high schools provided details on school and teacher information, students receiving peer instruction, peer instructors, assessments, and funding. Across all schools, 167 peer instructors provided one-on-one instruction using the CRP to 255 students in need of reading remediation. Of these 255 students, 87% received one-on-one instruction. Of the 167 peer instructors, eight students began the program as students. The majority (77%) of the peer instructors received college credit for their participation.

Harris, Marchand-Martella, and Martella (2000) investigated the effects of Project PALS on the reading performance of at-risk high school students. High school peer instructors and students in need of reading remediation were randomly assigned to dyads or triads. Peer instructors presented the CRP and also conducted rate and accuracy measures. Pre- to posttest data were collected on vocabulary and comprehension subtests of a standardized reading assessment, oral reading fluency (words read per minute) and accuracy, number of repeated readings on initial and final lessons, and lessons completed. Results indicated that students' performance on the standardized reading assessment increased as did their oral reading fluency. In general, the number of repeated readings decreased from the initial lesson to the final lesson completed.

Marchand-Martella, Martella, Orlob, and Ebey (2000) investigated the effects of Project PALS in a local high school setting with students with disabilities. Students receiving peer-delivered instruction were pre- and posttested on a standardized reading assessment; programmatic data were also taken. Data were gathered on the performance of the peer instructors as well. The results of this study showed that students receiving the intervention over 1 academic year across levels of the CRP showed stable grade level performance in vocabulary and an increase of one and a half grade levels in comprehension on the Gates-MacGinitie. Stable performance on this measure for both subtests was noted for the peer instructors. Other positive changes were noted as well (e.g., high program approval from peer instructors and learners). Interobserver agreement data indicated the peer instructors collected data with a high degree of accuracy.

Finally, Short, Marchand-Martella, Martella, Ebey, and Stookey (1999) assessed the advantages of serving as peer instructors in Project PALS at a local high school. Results showed that the peer instructors who scored below grade level on the vocabulary pretest of a standardized reading assessment increased to at or above grade level on the posttest; they exhibited stable performance on the comprehension subtest.

Thus, there is a promising research base demonstrating local capacity to conduct the project. However, all studies have been conducted in one geographic location and only one study focused on students with disabilities. None of the studies focused on culturally diverse populations such as Native Americans. Note that a recent report on reading and the Native American learner (OSPI, 2000) details the critical need to conduct further research with this population of learners in the area of reading.

Directions for Future Research

To date, four studies have been completed on Project PALS. Clearly, additional research is warranted evaluating the effects of peer-delivered instruction to teach reading. However, it should be stated that Project PALS has affected over 1,000 high school students who were poor readers and who have been taught using Corrective Reading materials over the past 5 years in the state of Washington alone. Therefore, the external validity of Project PALS seems solid. Unfortunately, as with most applied research, the research designs used to validate Project PALS have been pre-experimental to quasi-experimental designs. Therefore, a clear need of investigation surfaces using true experimental designs to demonstrate the internal validity of this promising program.

Second, peer-delivered instruction in other curricular areas should studied as well (e.g., mathematics). Peer-delivered instruction can be successful in delivering individualized mathematics instruction to a larger number of students (Fantuzzo, King, & Heller, 1992; Maheady et al., 1987; Schloss, Kobza, & Alper, 1997). For example, Schloss et al. (1997) investigated the use of peer instructors for teaching money skills to high school students with moderate mental retardation. Schloss et al. (1997) found that students benefited from skilled peer models and exhibited high rates of correct responses. Additionally, students' appropriate interactions and on task behaviors increased. In another study, Maheady et al. (1987) reported that students who were part of a peer tutoring program showed improved performance on weekly mathematics assessments. Finally, Fantuzzo et al. (1992) implemented reciprocal peer instruction with fourth and fifth grade students at risk for mathematics failure. Four out of five participating teachers reported improvements in student mathematics performance, social conduct, and social interactions.

We have begun investigating the effects of peer-delivered instruction in mathematics using the Corrective Mathematics program (CM) (Engelmann & Carnine, 1982). CM is a Direct Instruction program for students in grades 4-12 who are experiencing difficulties in mathematics. CM includes the following levels and modules: (1) Addition, (2) Subtraction, (3) Multiplication, (4) Division, (5) Basic Fractions, (6) Fractions, Decimals. The focus of the program is to teach specific strategies for learning and retaining facts, solving computational problems, and discriminating between and solving various types of story problems (Engelmann & Carnine). Targeted skills are organized into strands composed of structured lessons. Placement tests are used to assign students into specific skill books within the program so that time is not wasted on skills that students already know.

Parsons, Marchand-Martella, Waldron-Soler, Martella, and Lignugaris/Kraft (2002) investigated the effects of a peer-delivered CM in a secondary general education classroom with students with low mathematics performance. Ten learners and nine peer instructors participated in the study. Peer instructors instructed individuals or pairs of learners in the CM program for 10 weeks. Pre- and posttest data were collected on the learners and peer instructors using the Woodcock Johnson-Revised Tests of Achievement (WJ-R ACH) Calculation and Applied Problems subtests; in addition, the CM placement test was administered to the learners before and after the program. Results showed that students who were instructed by their peers with the CM program exhibited improved performance on the CM placement test and both subtests of the WJ-R ACH. Specifically, the learners' average improvement on the Calculation subtest was statistically significant. The performance of the peer instructors also improved on both subtests of the WJ-R ACH. The peer instructors' average improvement on the Applied Problems subtest was statistically significant.

Third, there is a need to determine the effects of peer-instruction on the peer instructors themselves. One study conducted by Short et al. (1999) assessed this issue. Although the results of this investigation were positive, more research is needed investigating this area.

Fourth, there is a great need to look for generalization to content area classes. For students in special education, the 1997 Amendments to IDEA contain several provisions that link the IEP to the general education curriculum. However, it is difficult for students to fully experience the benefits of the general education curriculum without sufficient reading skills. Graves (2000) notes that explicit strategies be used to teach reading in the content areas and that assessments occur in areas such as history and science (Polloway, Patton, & Serna, 2001). To date, there has not been a wide-scale demonstration of the generalizatbility of learned skills developed via peer-delivered Corrective Reading to content-area classes. Therefore, research is needed to demonstrate the generalization of reading (and other academic) skills learned via peer-delivered instruction combined with Corrective Reading in content area classes where content-rich selections are provided.

Finally, there is a need to move a program such as Project PALS to middle and elementary levels. Unfortunately, behavior analysts are required to remediate deficits later in a student's academic life. It seems especially important to prevent students from entering high school with a lack of academic skills. Although Project PALS has been successful in remediating reading problems at the high school level, the next evolution of the program and research on its success seems to be implementation earlier in a student's academic career.

Conclusion

Project PALS has been demonstrated to be an effective program in teaching reading skills to secondary-level students. The integration of two powerful procedures (Corrective Reading and peer-delivered instruction) has aided in the effectiveness of this program. Although there is information on the effectiveness of Project PALS, more research needs to be conducted to increase the internal validity of the project and to extend it to other areas and other types of students (e.g., middle schools). Finally, there is a need to demonstrate the generalized effects of the project to content areas. The use of effective behavior analytic technology will continue to improve the services we offer to schools. We feel that the direction that behavior analysis needs to go to have a wide impact on education is the implementation of large-scale implementations such as Project PALS.

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A SUMMARY OF THE EFFECTS OF REWARD CONTINGENCIES ON INTEREST AND PERFORMANCE

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In recent years, the view that rewards disrupt performance and motivation has gained popularity. This claim is primarily based on experiments from social psychological research. To evaluate the validity of this contention, a statistical analysis of more than 140 experiments concerning the effects of rewards on performance and interest was conducted (Cameron, Banko, & Pierce, 2001). The present article is a non-technical summary of this research. Our evaluation of more than thirty years of research indicates there is no inherent negative property of external reward. Careful arrangement of rewards in education, business, and home settings can enhance interest and performance. This occurs when rewards are closely tied to attainment of performance standards and to specific behavioral criteria.

In educational settings, teachers use praise, gold stars, access to preferred activities, and an array of incentives to promote learning. Businesses use pay, recognition, bonuses, or other types of rewards to encourage high levels of performance by their employees. Parents offer children rewards for doing well at school, for accomplishments in sports, and for progressive achievement in the arts. Given that rewards are widely used in everyday settings, it is noteworthy that some researchers and practitioners claim that rewards damage peoples' motivation and performance (e.g., Deci, Koestner & Ryan, 1999; Kohn, 1993). The argument is that individuals experience feelings of competence and self-determination when they enjoy what they are doing (Deci & Ryan, 1985). When offered a reward for performance, the claim is that people do the activity for the incentive rather than for internal reasons. The result is said to be a reduction in perceptions of competence and self-determination that in turn decrease motivation and quality of performance.

The view that rewards undermine motivation and performance is popular. As a result, many teachers are reluctant to use a reward system in their classrooms; the concern is that students will lose their motivation to engage in school activities. Our research suggests there is no inherent negative property of external reward (Cameron, Banko, & Pierce, 2001). Our analysis of more than thirty years of research concerning rewards and motivation indicates that rewards can be used effectively to enhance interest and performance. When rewards are tied to meeting attainable performance standards, motivation and performance are maintained or enhanced.

Research on rewards, motivation, and performance comes from experimental social psychology. Over the past few years, we conducted a series of analyses of this literature to determine when and under what conditions rewards produce increases or decreases in performance and interest (Cameron et al., 2001; Cameron & Pierce, 1994; Eisenberger & Cameron, 1996). In this article, we describe the experimental literature on this topic and outline how the findings were organized, analyzed, and integrated. We present a summary of our meta-analytic results and discuss the implications of the findings. For a detailed and technical description of our analyses, the reader is referred to our paper in *The Behavior Analyst* (Cameron et al., 2001).

RESEARCH ON REWARDS AND INTRINSIC MOTIVATION

The notion that rewards destroy an individual's intrinsic motivation led to a number of experiments. Since the 1970s, more than 140 studies, using a common set of procedures, have been conducted to investigate the alleged undermining effects of reward. In a typical experiment, people are presented with an interesting task (e.g., solving puzzles, drawing pictures, or playing word games) for which they receive praise, money, candy, gold stars and so forth. A control group performs the activity without receiving a reward. Both groups are then observed during a non-reward period in which they are free to continue performing the task or to engage in some alternative activity (free-choice period). The time participants spend on the target activity during this period, their performance on the task during the free-choice session, and their expressed interest in the activity are used as measures of intrinsic motivation. If participants in the reward condition spend less free time on the activity, perform at a lower level, or express less task interest than those in the nonrewarded group, reward is said to undermine intrinsic motivation.

In the early 1990's, we examined the experiments on reward and intrinsic motivation and found a mixed set of findings. In some studies, extrinsic rewards reduced performance or interest. Other studies found positive effects of reward. Still others showed no effect. Given the diversity of effects, we conducted a meta-analysis of 96 experimental studies and concluded that there is reason to challenge the view that rewards are predominantly harmful (Cameron & Pierce, 1994). The 1994 meta-analysis indicated that negative effects of reward were limited and that rewards contingent on performance did not undermine measures of intrinsic motivation (also see Eisenberger & Cameron, 1996).

Our findings were contentious (Kohn, 1996; Lepper, Keavney, & Drake, 1996; Ryan & Deci, 1996), and resulted in another meta-analysis of the literature (Deci et al., 1999). The meta-analysis by Deci et al. (1999) included 128 experiments (including unpublished dissertations) and the results were organized in terms of cognitive evaluation theory, a major cognitive account of how rewards have detrimental effects. Based on this theoretical view, Deci and his associates concluded that rewards have pervasive negative effects on intrinsic motivation. In 2001, we re-analyzed the literature (based on 145 experiments) and found that, when studies are organized according to the actual procedures used (rather than by theoretical orientation as was done by Deci et al., 1999), rewards produce different effects depending on the reward contingency (Cameron et al., 2001). The next section of this article describes our meta-analytic procedures and findings.

CONDUCTING A META-ANALYSIS

Meta-analysis is statistical technique for combining the results from a large number of studies on the same topic (for a technical discussion of meta-analysis, see Hedges & Olkin, 1985). It involves the statistical analysis of a large collection of results (effect sizes) from individual studies to integrate the findings.

In the present case, effect sizes (standardized differences between experimental and control groups) were assessed from experiments in which a rewarded group was compared with a non-rewarded control group on measures of intrinsic motivation. The main measures of intrinsic motivation are (a) performance (time and behavior on task during the free-choice period) and (b) self-reported task interest.

There are several steps to meta-analysis that were used in the current research (Cameron et al., 2001). The first step was to specify the research questions. The questions addressed were:

- Do rewards overall lead to a decrease in interest and performance (intrinsic motivation)?
- Under what conditions do rewards lead to decreased or increased intrinsic motivation?

Other steps in meta-analysis involved specifying the criteria for including and excluding studies, collecting all experiments that met the criteria (145 independent studies were included), reading and coding the studies, calculating effect sizes, and performing statistical analyses of effect sizes using a computer program called Meta (Schwarzer, 1991).

We conducted a hierarchical meta-analysis that began at the level of all rewards across all types of activities and tasks. This overall analysis was designed to answer the question of whether rewards are generally harmful to interest and performance. Next, we examined the effects of different moderator variables; the first breakdown was in terms of high and low initial task interest. Few studies used experimental tasks or activities of low initial interest and we were unable to conduct further moderator analyses. On tasks with high initial interest, however, studies were subdivided by reward type (verbal and tangible); tangible rewards were further broken down by reward expectancy (expected and unexpected) and the effects of expected tangible rewards were further subdivided into a number of reward contingencies. At the final level of analysis, reward contingencies were analyzed that used maximum versus less than maximum reward.

SUMMARY OF META-ANALYTIC FINDINGS

A summary of the meta-analytic findings is presented in Figure 1. Analyses are arranged hierarchically with the more general categories at the top of the diagram. First, we present the overall effects of reward; studies are then broken down into subsets based on moderator variables. A positive effect indicates that rewards increased the measure of intrinsic motivation relative to a nonrewarded control group and a negative effect indicates that rewards decreased intrinsic motivation. Statistically significant mean effect sizes are presented in the Figure; non-significant values are denoted as n.s. According to Cohen (1988) a mean effect size of 0.20 is considered small, 0.50 is moderate and greater than 0.80 is large.

Our first research question concerned whether rewards, in general, decrease peoples' intrinsic motivation. In terms of the overall effects of reward (all reward), Figure 1 indicates that there is no evidence for detrimental effects of reward on either measure of intrinsic motivation (performance or task interest). In fact, there is a slight positive effect of overall rewards on task interest. These findings indicate that rewards are not inherently harmful.

EFFECTS OF REWARD ON LOW AND HIGH INTEREST TASKS

Our overall analysis shows that rewards do not have generalized negative effects. Several researchers, however, have suggested that level of initial task interest is of prime importance (see Deci et al., 1999). The claim is that if people enjoy an activity, rewards will destroy their intrinsic interest. Those who espouse the view that rewards are detrimental to intrinsic motivation have expressed little concern about the effects of rewards on low interest tasks. Applied behavior analysts, on the other hand, are interested in reward procedures when initial interest varies. In fact, few behavior analysts would recommend setting up a reward system for activities that people already perform at a high level; most programs of reward are designed to instill interest in tasks that hold little initial appeal. Thus, we conducted an analysis of the effects of reward on tasks of low and high initial interest.

All studies were coded for initial levels of task interest based on measures reported in the studies. Studies without initial interest measures were classified as high or low interest depending on how the original researcher defined the task, or on whether the task had been described as interesting or uninteresting in prior experiments.

The results from our analysis (Figure 1) show that when the tasks used in the studies are of low initial interest, rewards increase performance (effect size = 0.28), but do not affect interest. These findings indicate that rewards can be used to enhance time and performance on tasks that initially hold little enjoyment. As we stated in our article (Cameron et al., 2001):

> In education, a major goal is to instill motivation and enjoyment of academic activities. Many academic activities are not of high initial interest to students. An implication of our finding is that rewards can be used to increase motivation and performance on low-interest academic activities (p. 21).

The majority of the studies included in our meta-analysis used tasks of high initial interest. This is not surprising because according to those who hold the detrimental effect view, rewards cannot disrupt intrinsic motivation if there is little or no initial interest in an activity. On high interest tasks, Figure 1 indicates a negative effect on performance but a positive effect on task interest. Although both effects were statistically significant, the effect sizes were close to zero. The negative effect of reward on the performance measure, at first glance, seems to provide support for the view that rewards have detrimental effects on high interest tasks. Further analyses, however, indicate that the effects of reward depend on the reward type, the reward expectancy, and the reward contingency.

EFFECTS OF REWARD TYPE ON HIGH INTEREST ACTIVITIES

On activities with initial high interest, rewards were either verbal (praise and positive feedback) or tangible (money, good player awards, candy, etc.). Figure 1 shows that the use of verbal rewards resulted in small to moderate increases in task performance and interest. People who received praise for performance showed higher levels of intrinsic motivation than those who did not receive verbal rewards. One implication of these findings is that verbal rewards can be used in applied settings without detrimental effects. In fact, when praise is given for accomplishments, people will continue to perform and enjoy an activity even when praise is no longer forthcoming.

As shown in Figure 1, tangible rewards had a small negative effect on performance but a slight positive effect on interest. The reduction in performance by tangible rewards appears to be consistent with the view that rewards are negative. However, the finding is not straightforward. As we proceed from the general classification of all tangible rewards to more specific categories, the negative effect is revealed to be conditional and limited.

EFFECTS OF TANGIBLE REWARD EXPECTANCY ON HIGH INTEREST TASKS

One procedure that differed over studies was whether the tangible rewards were expected or unexpected. In experiments involving expected rewards, participants were offered a reward before they engaged in the experimental activity; the reward was delivered after they had worked on the task. In other studies, the participants were given the reward after they engaged in the task but were not offered it prior to their involvement (unexpected rewards). We were able to break down experiments on tangible rewards into expected and unexpected; reward expectancy was not systematically manipulated in studies of verbal rewards.

When tangible rewards were broken down into expected and unexpected, Figure 1 shows that there were no significant effects for unexpected tangible rewards on either the performance or interest measures. That is, if participants were given a tangible reward but not offered it prior to engaging in the experimental activity, intrinsic motivation was not altered. Tangible rewards that were offered beforehand (expected) produced a negative effect on performance, but a slight positive effect task interest. These findings suggest that it is not tangible rewards, per se, that undermine performance; instead it depends on instruction and the statement of contingency.

EFFECTS OF EXPECTED TANGIBLE REWARD CONTINGENCIES ON HIGH INTEREST TASKS

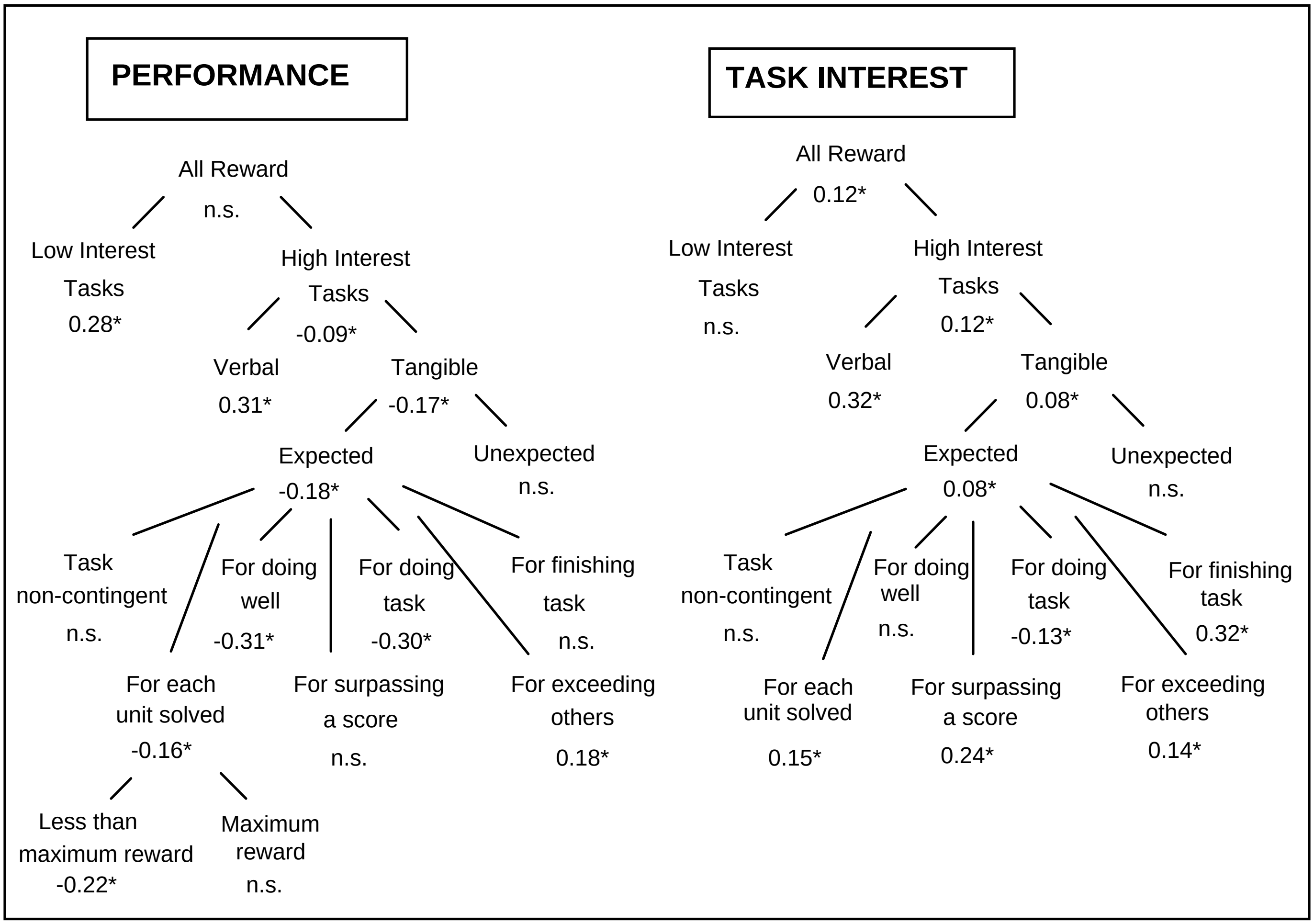
At the next level of analysis, expected tangible rewards were categorized according to the description of the reward contingency. Using a procedural classification of reward contingencies, studies were organized into seven main categories: 1) rewards delivered regardless of task involvement (task non-contingent), 2) rewards given for doing a task, 3) rewards for doing well, 4) rewards for finishing or completing a task, 5) rewards given for each problem, puzzle, or unit solved, 6) rewards for achieving or surpassing a specific score, and 7) rewards for meeting or exceeding others.

As a supplementary analysis, studies were labeled "maximum" reward if participants in the reward condition met the performance requirements and received the full reward. "Less than maximum" reward occurred when there was a time limit such that some participants did not meet all the requirements and were given less than the full reward. There was only one reward contingency – rewards offered for each unit solved – that allowed for a comparison between maximum and less than maximum reward. For other reward contingencies, too few studies involved less than maximum reward and a meta-analysis was not feasible.

On the performance measure, Figure 1 shows that when the offer of reward was unrelated to task behavior (task non-contingent), there is no evidence for an effect of reward. On the other hand, when people are offered a tangible reward for doing a task or for doing well at a task, they perform at a lower level in a free-choice period. Generally, these findings suggest that when the description of the reward contingency implies that rewards are loosely tied to behavior, people show a small reduction in performance. In contrast, when rewards are specifically tied to finishing a task, Figure 1 indicates no significant effect on performance.

Figure 1 indicates that rewards offered for each unit solved (reward per unit) have a negative effect on the performance measure. This finding is seemingly at odds with an interpretation that rewards can have negative effects on performance only when the rewards are loosely tied to behavior. Additional analysis in terms of maximum and less than maximum rewards helps to resolve this discrepancy.

The results in Figure 1 show that the negative effect on performance, of rewards offered for each unit solved, occurs when participants obtain less than the full reward. In studies of less than maximum reward, participants are given a time limit to solve problems. Thus, the negative effect may be a result of time pressure rather than reward. Another way to understand this result is to consider what less than maximal reward signifies to participants. If people are told they can obtain a certain level of reward but are given less than that level, they have received feedback that indicates failure. In other words, this type of situation may represent failure feedback, not reward. When participants are not under a time pressure and are able to obtain the maximal reward, there is no reliable effect on the performance measure.



When rewards were offered for meeting or surpassing a score, Figure 1 shows no reliable effect on performance. However, when rewards were given for exceeding the performance level of others, the results show a significant increase on free choice.

The data concerning task interest provide little evidence for decremental effects of tangible expected reward. Figure 1 shows that expected rewards (a) have no effect when they are non-contingent or offered for doing well on a task, (b) produce a negative effect when they are offered for doing the task, and (c) lead to increased expressed task interest when they are offered for finishing a task, for each unit solved, for surpassing a score, and for exceeding others. Thus, on task interest, the only negative effect occurs when the rewards are tangible, expected, and given simply for engaging in an activity without regard to any performance standards.

Overall, our meta-analysis shows that rewards can be used to produce both negative and positive effects on measures of intrinsic motivation. Rewards can be used to increase motivation and performance on tasks that are of low initial interest. On high interest tasks, positive effects are obtained when participants are verbally praised for their work and when tangible rewards are offered and explicitly tied to performance standards and to success. Negative effects are produced when rewards signify failure or are loosely tied to behavior.

WHAT THE META-ANALYTIC RESULTS REVEAL

Our meta-analysis suggests that negative effects of reward on intrinsic motivation are circumscribed and limited. The experimental studies we have described concern levels of performance and interest after rewards are withdrawn. In addition, the reward procedure is typically in effect over a single session followed by a single assessment of performance and interest following the removal of reward. In five operant studies (not included in our meta-analysis because of their unique designs) participants' performance on a task was observed over a number of sessions (baseline) in a non-reward phase (Davidson & Bucher, 1978; Feingold & Mahoney, 1975; Mawhinney, Dickinson, & Taylor, 1989; Skaggs, Dickinson, & O'Connor, 1992; Vasta, Andrews, McLaughlin, Stirpe, & Comfort, 1978). Reward was then presented over a number of sessions followed by repeated assessments of performance in the absence of reward. Intrinsic motivation was measured as the difference in performance between pre- and post-reward phases. None of these studies showed a decremental effect of reward on performance (see Cameron & Pierce, 1994; Eisenberger & Cameron, 1996). That is, performance in the post-reward phase recovered to a level that matched or exceeded the pre-reward phase. In other words, when performance is measured over many sessions, any decline in performance following the removal of reward recovers.

In the context of these findings, one way to understand the results of the meta-analysis is that the decremental effects of rewards are temporary. Does this temporary change indicate a change in people's intrinsic motivation? It does not appear so. The negative effect that we have detected in our meta-analysis occurs only when loose reward contingencies have been in effect and are withdrawn.

The temporary negative effects of tangible reward on high interest tasks could be due to well-known principles of reward and reinforcement. For high interest tasks, our meta-analysis shows a difference between tangible and verbal rewards. Carton (1996) noted that in studies of verbal reward, the rewards were given immediately, frequently, and without any indication of reward withdrawal. These procedures are typical of a contingency of reinforcement and would be expected to increase performance and interest. Our findings that verbal rewards increase performance and interest are in accord with this hypothesis.

Carton has suggested that in studies of rewards and intrinsic motivation, tangible rewards are usually delivered only once with some delay between the performance and the reward. Generally, then, tangible rewards are expected to have a negative effect because the rewards are unlikely to be functioning as reinforcement. In addition, in such studies, participants are often told (or it is implied) that the rewards are no longer available for the free-choice session. These signals of reward withdrawal could reduce on-task performance when participants are free to choose among activities. Our meta-analytic results indicate a general negative effect for tangible reward that could support Carton's hypothesis. This account is given more support by the single-subject studies on the topic. In these studies, tangible rewards were delivered repeatedly and immediately; no detrimental effect of reward was detected, presumably because the rewards functioned as reinforcement.

Results from our meta-analysis indicate that tangible rewards produce negative effects when they are offered for doing a task or for doing well. When non-reinforcing rewards are offered for simply doing a task (with no regard to quality or level of performance), one possibility is that they act like demands. Participants may view these non-reinforcing rewards as an attempt to force them to behave in a given way and they may react against the experimenter's control by showing deliberate non-compliance. The deliberate non-compliance could also be a reaction to the coercive offer of the reward by the experimenter. The coercive aspect of the situation would be more prominent when rewards are given without regard to level of performance. Under these conditions, participants may react by reducing their time and performance on the task in the free-choice phase.

In our meta-analysis, when tangible rewards were offered for each unit solved, a negative effect occurred when participants received less than maximum reward. In this context, less than maximum reward could indicate failure. Failure is a conditioned punisher that would temporarily decrease task performance during the free-choice period. Also, because failure is paired with the natural rewards of performing the activity, the value of the natural consequences, could decrease. Repeated encounters with failure could, in this way, undermine motivation. In contrast, when rewards are offered for success, for meeting or surpassing a performance standard or group norm, our meta-analysis indicates that performance and interest were maintained or enhanced. These reward procedures could be called "success-contingent" (see Dickinson, 1989). Such rewards would function as conditioned reinforcement and during the free-choice period, on-task behavior would be maintained.

The finding that rewards increase performance on low interest tasks is most important from a behavior-analytic perspective. That is, our finding that rewarding performance on activities of low initial interest increases measures of intrinsic motivation suggests that rewards may be used without detrimental effects under conditions where they are most important (i.e., when people have little initial interest in the activity). Under these conditions, extrinsic rewards do not conflict with the natural consequences of the activity and do not subvert performance and interest.

USE OF REWARD CONTINGENCIES IN EVERYDAY LIFE

As indicated in our meta-analysis, detrimental effects of rewards on performance and interest are highly restricted. One may be able to produce a negative effect of reward in the laboratory but an unusual combination of conditions is necessary. To produce the phenomenon, the following must occur:

- the activity must be of initial high interest (using rewards with low interest activities does not produce a negative effect).
- the delivery of reward must be stated beforehand (unexpected rewards do not produce a negative effect)
- rewards must be material or tangible (verbal praise does not produce a negative effect)
- the reward contingency must be loose or vague (rewards given for success or for meeting a performance do not produce a negative effect)
- the reward must be delivered only once over a single reward session (repeated delivery of rewards does not produce a negative effect)
- intrinsic motivation must be indexed by measures of performance or interest following the withdrawal of reward (measuring intrinsic motivation during the rewarded period does not produce a negative effect).
- intrinsic motivation must be assessed only once following the removal or rewards (repeated measures of performance and interest show no negative effects following the removal of reward).

Clearly, the conditions that produce negative effects are of no great social importance. One would be hard pressed to find any real life circumstances that directly parallel the laboratory conditions necessary to produce a negative effect. It is difficult to imagine an employer who would shower incentives on employees for a temporary period, regardless of how they behave, withdraw the system, and then expect employees to work hard after hours. In educational environments, students are rarely rewarded simply for doing activities they already enjoy. Rewards are most often used to shape successful performance and to recognize students' accomplishments. In addition, the rewards are usually presented over a period of time and as proficiency in an activity increases, the rewards are gradually faded out. In contrast, in the typical between-groups reward and intrinsic motivation experiment, the procedure involves a single reward delivery followed by a single assessment of intrinsic motivation without reward. The point is that the procedures used in the experimental studies to obtain negative effects of reward on intrinsic motivation are not characteristic of the use of rewards in applied settings.

The comparability of the reward contingencies used in the laboratory experiments to those used in everyday settings is frequently ignored in discussions that emphasize the detrimental effects of reward on intrinsic interest. Instead, those who argue that negative effects are pervasive tend to condemn the use of rewards in practical settings. Thus, it is important to consider any circumstances that could remotely resemble the laboratory conditions shown to produce a negative effect of reward.

In work settings, there are some circumstances in which individuals are rewarded irrespective of success or performance level. For example, because of compensation and promotion systems that are insensitive to performance (e.g., wage by job classification), some employees can vary their performance substantially with little effect on tangible reward. In such a situation, employees may have considerable latitude in how well or poorly they perform their jobs without any change in pay or fringe benefits. If an employee has high intrinsic interest in the job and receives a reward independent of performance, interest in the job may decrease, thereby producing poorer performance than if the reward were contingent on performance.

In educational settings, if a student has high interest in a particular subject matter, say a history course, and receives the same grade regardless of performance, interest in history could deteriorate. The student may be less likely to spend time reading history books during the course and following the conclusion of the course. To avoid poor performance and reduced task interest in business and educational settings, employers, teachers, and administrators need to consider the basis upon which they allocate rewards, recognition, and advancement. Our meta-analysis suggests that when people are praised or given positive feedback for their work, task interest and performance increase. When tangible rewards (e.g., money) are made contingent on success or on meeting a performance standard, motivation is enhanced.

CONCLUSION

In this article, we have presented a summary of our meta-analytic findings on reward and measures of intrinsic motivation. The results show that rewards are not inherently good or bad for people. Rewards can have negative effects but these effects are circumscribed, limited, and easily prevented. Careful arrangement of rewards in business and educational settings can enhance employees' and students' interest and performance. The most important requirement is to closely tie rewards to meeting attainable behavioral criteria and performance standards.

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BEHAVIOR THERAPY AND AUTISM: ISSUES IN DIAGNOSIS AND TREATMENT

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Behavior analysis has demonstrated utility when it comes to the treatment of autism. Still behavior analysts continue to refine and develop their techniques. This article conceptualizes autism within a behavior analytic model of child development and characterizes several promising techniques for increasing language use and spontaneity. These areas are detailed sufficiently to inspire new research and aid consultants in designing interventions and a more comprehensive curriculum for children with autism.

For behavior therapists and specialists, developmental psychopathology is an area of growing interest. Developmental psychology is the field of psychology-concerned changes in the individual across the life span. To accomplish this task, this approach attempts to observe children/adults over extended periods. Psychopathology is the area of psychology that studies clusters of behaviors that predict decreases in life satisfaction or ability to function. Together these two areas combine to study and predict long term outcomes for a child with behavioral patterns considered problematic (Rutter, 1994). One clusters of behavior patterns receiving particular attention by behavior specialists and therapists is children with autism. This article attempts to provide a review of state of the art treatment of autism for those working in the field.

Autism comes from Greek, meaning stereotypy. The term autism was first used by Bleuler to describe a patient who withdrew socially from his environment (Kanner, 1971a). Several case studies of this syndrome were identified between Bleuler and Kanner. In 1943, Kanner applied the label of autism to eleven children who were socially aloof and self-isolated from a very early age. He studied these children extensively from early childhood through adulthood. After his study, he presented a detailed account of the children's adjustment and placement (Kanner, 1971b). He described the prognosis for this disorder as poor.

In Kanner's view, infantile autism was distinctly different from mental retardation, other disorders and childhood schizophrenia. Since children with retardation are generally responsive to adults, Kanner used the lack of social responsiveness to support the conditions as distinct "disorders." With conditions like schizophrenia, the child would obtain a "normal" level of functioning and then would have withdrawn from that level. In contrast autism is a syndrome where the child has never functioned at an adequate level. Also, having autism does not place the child at a greater risk of developing schizophrenia then the general population (Volkmar & Cohen, 1991). Also, in general children with autism have poorer social skills and show marked deficits in language (Matese, Matson, & Sevin, 1994). This suggests that these disorders may have different origins (Margolies, 1977).

The most defining feature of autism, according to Kanner (1943), was the child's inability to relate to other children and adults. Under this umbrella, he defined the following characteristics: disruption in language development; or a complete failure to develop language; a need to maintain a constant environment (no changes); monotonous repetitions of behavioral sequences such as hand flapping or twirling; good intellectual abilities in very restricted areas; and little spontaneous play activities.

Current Issues in the DSM-IV Diagnosis

The patterns of behavior diagnosed as autism occurs in 4.5 out of 10,000 children. Although Kanner believed autistic children were of average intelligence, this is most often not true (Rutter, 1983). Consistently, empirical investigations reveal approximately 80 percent of children with autism score below 70[1] on standardized intelligence tests,

[1] Standardized IQ scores are being used here not because the authors believe that such tests measure "Intelligence" but because these scores are predictive of long term academic achievement.

placing them within the range of mental retardation (Ghaziuddin, Tsai, & Ghaziuddin, 1992; Rutter, 1983). Since the scores for the two groups (mental retardation and autism) are similar, sometimes they are hard to differentiate (Kamphaus & Frick, 1996). One area often used to make a differential diagnosis is children with retardation often display delays in areas of gross motor development such as learning to walk, while children with autism can be quite graceful (Rutter, 1983). Also, other developmental problems, which are more common and have better prognoses than autism, need to be differentiated from the autism diagnosis. Autism is one of the most difficult disorders to diagnosis. Also a dearth of instruments exists to aid the clinician (Kamphaus & Frick, 1996). Poor ability to diagnosis has led to exaggerated claims of "cures."

The diagnosis of autism is stable and does not appear to remit spontaneously or even through special education services (Eaves & Ho, 1996; Jacobson & Ackerman, 1990). Since the DSM III-R, a developmental age has been added. This age is thirty-six months, which is the condition must be evident by thirty-six months of age. Suggesting autism symptoms gradually manifest themselves from infancy to thirty-six months (Freeman & Ritvo, 1984).

TREATMENT

Behavior Analysis and Child Development

Since developmental changes over extended periods are lacking not just in autism but in most child pathology (Wierson & Forehand, 1994), autism intervention, comes from the developmental theory of the behavior specialist. Theory guides treatment, explaining how behavior changes and how children become functioning adults. Both the strengths and weaknesses of current behavior therapy stem from its theoretical underpinnings of child psychopathology. To date the greatest impact on behavior analytic thinking in child development is the work of Sidney Bijou and Donald Baer (Bijou, 1968, 1989, 1993; Bijou & Baer, 1961, 1965, 1978). Bijou and Baer drew on the writings of Skinner (1953) and Kantor (1963). Their developmental theory details how a child's genetic program interacts with experiences and current environmental circumstances to produce changes in behavioral repertoires. The theory attempts to explain how repertoires combine and reform into new ones (Johnson & Layng, 1992).

Behavior analysis of child development (1) relies heavily on learning processes/social interaction as the fundamental basis of psychological development and (2) avoids making causal statements on unobservable processes, holding these processes themselves are in need of explanation (Bijou, 1968). Thus interventions for autism involve habilitation-teaching new skills- instead of focusing on psychological trauma.

Several skills are critical to changing the developmental course of autism: language (Lovaas, 1973); imitation (Smith & Bryson, 1994); social interactiveness (Krantz & McClannahan, 1998); and multiple stimulus control (i.e., where the child is under stimulus control of both the parent and the object simultaneously and the parent is under stimulus control of the child and the same object) called joint attention (Greenspan, 1992; Klinger & Dawson, 1992; Warren, Yoder, Gazdag, Kim, & Jones, 1993).

General Treatment Considerations

While behavior analytic literature in developmental disabilities focuses on building skills, institutions and families most often call on behavior specialists to design programs to reduce problematic behaviors (Holburn, 1997; Glenn, Ellis, & Hutchinson, 1993; Holland, 1973). This is unfortunate for both our profession and our clients, for "recovery," are linked to behavioral acquisition and not reduction. Thus, it is our general recommendation that behavioral programs focus on building new skills (Risely, 1996). Such programs for autistic children should focus on improving communication, social skills, and adaptive behavior so that children with autism can become more appropriate in interaction with the community. Good consultation / therapy will focus on behavioral development. As a secondary concern, a program should relieve problematic behaviors. Of course if the child is in danger due to self injury then the pattern is reversed.

Therapists teaching children with autism need to be aware of certain difficulties. Children with autism have several problems that inhibit training (Lovaas, 1977; Naglieri, 1981). One pattern in children with autism is they have aversive reactions to changes in routines, often exhibiting tantrums and crying (Dawson & Osterling, 1996). These tantrums can occur over changes in direct care staff, substitute teachers in school, or even more subtle changes in routine.

Second, their behavior problems and self-stimulatory movements inhibit effective training (Rimland, 1964). These movements do not appear to have effects on the ability of the child to learn, they do appear to have effects on the teachers' ability to teach effectively. Although similar behaviors are expressed in children with other disabilities, they do not have the same frequency, severity and duration. Recently, to avoid some of these effects on teachers many programs have begun to use computer assisted instruction techniques.

Third, it may be particularly difficult to find reinforcers for children with autism. When conducting a reinforcer preference survey with children without the pattern of behavior, the therapist can rely on observing the child while they explore their surroundings. In general children who display autistic patterns of behavior tend not to explore surroundings. Another issue in children with this pattern of behavior is that reinforcers to be effective must be explicit, concrete, and/or highly "salient" (Hewett, 1965; Lovaas et al., 1966). To counter, a therapist needs to use methods of increasing the range of reinforcers that children with autistic patterns will respond. Pairing social reinforcement with primary reinforcers, such as food, is common (the earliest study to use this technique was Lovaas et al. (1966).

An issue currently under debate with children with autistic patterns, but may be considered a problem, is selective attention (Lovaas, 1977; Lovaas, Schreibman, Koegel, & Rehm, 1971; Rincover & Koegel, 1975) or for behavior analysts coming under stimulus control[2] of irrelevant details of the context. When a child's attention becomes focused on one aspect of a task or situation, they may not notice other properties, including relevant ones. An additional concern, one which educators and therapists of autistic children share is the youngsters' inability to generalize learning. Over selective patterns displayed in children with autism make generalization difficult. However, some have questioned overselectivity. Overselectivity may be an issue of the training methods and procedures used, especially those used in discrete trial formats that do not take advantage of the "train loosely" generalization procedures suggested by Stokes & Baer (1977). In spite of all these problems, educational programs for students with autism have achieved some impressive results (Foxx, 1993; Kazdin, 1993a; Lovaas, 1987).

A considerable amount of effort since the 1960s in designing, carrying out, and assessing behavioral treatments for children with autism (see Schriebman, 1988 for an extensive review) has occurred. According to Matson and colleagues (1996) over 550 studies have been published showing the efficacy of behavioral procedures in building a wide range of skills for people with autism at all ages. In short behavior therapy is the most productive treatment children with autism (Foxx, 1993; Handleman, 1986; Koegel, Rincover, & Egel, 1982; Lovaas, 1981; O'Leary, 1984; Lovaas & Smith, 1988, 1989; Margolies, 1977). Even though this is the case, some have questioned the effectiveness of behavior therapy in comparison to other methods (Herbert & Brandsma, 2002).

Behavior therapy techniques take the form of operant conditioning and modeling. Through such procedures behavioral therapists have taught children with autism spectrum disorders to develop many skills. These have included displaying appropriate affective responses (Gena, McClannahan, & Poulson, 1996), to talk (Hewitt, 1965; Lovaas, 1966, 1977), ending echolalic speech (Carr, Schriebman & Lovaas, 1975; Foxx & Faw, 1990, 1992; Faw, McMorrow, Kyle, & Bittle, 1988), and playing with other children (Ceiliberti & Harris, 1993; Romanczyk, Diament, Goren, Trundell, & Harris, 1975). Other skills that have been taught with these strategies are playing symbolically (Stahmer, 1995), imitating others (Young, Krantz, & McClannahan, 1994), and self-management (Dunlap, Vaughn, & O'Neill, 1998; Koegel, Frea, & Surratt, 1994).

Discrete Trial Training

Lovaas developed an intensive operant treatment program for children with autism (Lovaas, Koegel, Simmons, & Long, 1973). Often the literature calls this treatment Lovaas Therapy or discrete trial training (Lovaas, et al., 1973; Lovaas, 1977). In 1973 the first outcome data appeared (Lovaas et al., 1973). Children's ages varied from three to nine and all therapy was clinic based. The study showed operant

[2] This form of stimulus control might be considered tight in the sense that it accounts for a high percentage upon which the probability of the behavior occurs

technology could teach complex language. Unfortunately, after treatment ended children regressed. Lovaas (1973) reported no children as "recovered" and follow-up showed failures in both maintenance and generalization.

Lovaas and colleagues (1973) believed language was the pivotal behavior. They focused efforts on increasing expressive, receptive, conversation, and complex language skills that all other skills, such as toy play, peer play, and socialization would follow. Generalization to other areas failed. As a result of the 1973 study, treatment focused on younger children (Lovaas, 1987).

During the ensuing years many experimented with Lovaas' training techniques particularly those in language training. In one study, Campbell and colleagues (1978) showed Lovaas training could be enhanced with haloperidol. They used children from 2 ½ years old to 7, comparing contingent vs. noncontingent reinforcement and drugs vs. nondrugs. Their measure was the number of words imitated by the child in each session. The combination of contingent reinforcement and haloperidol proved superior to either treatment alone.[3]

In the next study, Lovaas' (1987) treatment lasted for two to five years, forty hours a week, and took place in the home. The children were younger than four. The only exclusionary criterion was that the child did not have any severe medical disorders or a prorated mental IQ of less than twenty. Otherwise the child's autism was exacerbated by the medical condition or the mental retardation. At intake the children's IQs averaged fifty-four. There were three groups of children one group, which received forty hours of one to one discrete trial therapy, and two control groups. All three of those groups were matched on twenty pre-treatment variables, such as self-stimulatory behavior, language, half of the children were functionally mute, and half of the children were echolalic. The children in the active treatment component were reinforced for being less aggressive, more compliant, and more socially appropriate including talking and playing with other children. In the interim of those two studies it was found that the treatment worked better when the treatment used common objects from the home and those objects were still there after treatment ended.

[3] Readers who are interested in a review of pharmacological treatments in autism might wish to check out Handen (1993).

There were nineteen children in the experimental group and nine of the nineteen or 47% achieved normal functioning. With two years of intensive therapy, their measured IQs averaged 83 in first grade compared to about 55 for the controls. The finding of a forty to fifty percent recovery rate from ABA is stable in the literature (Birnbrauer, & Lich, 1993; Fenske, Zalenski, Krantz, & McClannahan, 1985; McEachin, Smith, & Lovaas, 1993). If these findings are close to accurate, then an underestimate is Lovaas therapy in early intervention will save the state $2,460,402 by the time the child is fifty-five (Jacobson, Mulick, & Green, 1998).

The first control group was 20 children who received 10 hours of therapy each week. Their IQs regressed at an average of five points. The second control group did not receive therapy; they were referred to an outside referral source and matched on the pre-treatment variables for the control for "placebo effects." While treatment gains were impressive and encouraging (Greene, 1996; Maurice, 1996), small sample size prohibits attributing the gains directly to the behavioral intervention (Schopler, Short, & Mesibov, 1989; Gresham & MacMillan, 1997) and lack of randomization of sample led to calls for replication (Kazdin, 1993a).

In 1993, there was a follow up study to look at the same children who were in the 1987 study (McEachin, Smith, & Lovaas, 1993). All of the children had maintained their gains. Nine out of the nineteen achieved normal functioning, eight out of the nineteen were placed in language delayed classes and two out of the nineteen were placed in classes for children with autism. The outcome for those eight out of nineteen who were placed in language delayed classes is somewhat variable. Over the course of time, into adolescence and adulthood they were able to hold a job and live independently or somewhat independently holding onto their gains and building upon them. Mortenson and Smith (1996) replicated Lovaas (1987) in a different geographic region. In this study treatment consisted of thirty hours of one to one therapy. The recovery rate was forty percent. Lovaas' program thus has both longitudinal data and a replication to support it.

In analysis of those that don't succeed the concept of visual learners was developed. Visual learners are the children who early in treatment either fail to acquire verbal imitation skills or do so at a slow pace. They have difficulty with auditory programs. In the past these children were taught sign language. Unfortunately, sign language has limited accessibility to the general population. What is implemented now is a reading and writing program. The purpose of the program is to teach children to communicate through reading and writing and other visual means. The goal of reading and writing projects is that by teaching children to cue into communication by a visual means, they will bridge the gap between visual and auditory discrepancies.

One of the training problems with discrete trial is of course that trial situations bear little resemblance to a natural world. Thus over prompting can block learning (i.e., most-to-least) in no prompt situations. One way to over come this problem is to match the prompting (i.e., least to most or most to least or some variation) to discriminative stimuli in the natural environment (McCoville, Hantula, & Axelrod, 1998). According to several researchers (McCoville, Hantula, & Axelrod) the moderating variables that guide in the selection of successful prompting needs to be explored in greater detail. Finally, training skills from a functional, free operant perspective might enhance the fluency of use (Johnson & Layng, 1996).

Functional Analysis and Language

Functional analysis emerged from Skinner's (1953) three-term contingency model, which Bijou (1968) later expanded to include the notion of setting events or establishing operations (Michael, 1982, 1885, 1988). This model built hypotheses about the function of behavioral excesses (Carr, 1977) and later deficits (Daly, Witt, Martens, & Drool, 1997). This emerging technology is considered the hallmark of good behavioral intervention designed by behavior specialists and therapists (Scotti, Schulam, & Hojnacki, 1994), increasing the overall durability of treatment (Foxx & Faw, 1990). For example, Foxx and Faw discovered that functional analysis plus intervention led to reduction of echolalic speech on follow-up of fifty-seven months. Yet, some have reported that functional analysis has been slow to making its way into interventions (Scotti, McMorrow, & Trawitzki, 1993).

In a functional analysis, behavior therapists divide behavioral excesses into four functions: escape, attention, tangible, and sensory automatic reinforcement. Since other people mediate three of these four basic functions, one can view the behavior as communicative. Thus, behavior therapists can differentially reinforce a replacement verbal skill for aberrant one. Functional language training combined with extinction of the inappropriate behavior leads to rapid reduction in severe disruptive and aberrant behavior (Day, Horner, & O'Neill, 1994; Lalli, Casey, & Kates, 1995; Hagopian, Fisher, Thibault-Sullivan, Acquisto, & LeBlanc, 1998). This stresses the need for behavior specialists to train functional language before disruptive behavior emerges.

In language intervention, behavior analysis is the dominant model (Goldstein & Hockenberger, 1991). It accounts for a third of empirical intervention articles. Much of the research has been conducted on autism and mental retardation (Goldstein & Hockenberger, 1991). It has lead to improvement of language skills, including affect related expression (Matson, 1982).

Initial language training programs focused on training linguistic structure (Andresen; 1991; Bricker, 1993), in mass trials, and training language receptively (Lovaas, 1973). Undoubtedly this was inspired by the Chomsky's (1959) critique of Skinner's (1957) book *Verbal Behavior.* This critique highlighted the importance of language structure. It has taken many behavioral replies to refocus language studies on function (e.g., Wiest, 1967; Salzinger, 1970, 1973, 1979; MacCorquodale, 1970; Catania, 1972, 1973; Verhave, 1972; Bricker & Bricker, 1974; Segal, 1975; Richelle, 1976; Shappard, 1988; Andresen, 1991).

In the 1980s researchers began to question the generalization of such skills (Warren & Rogers-Warren, 1980). This led researchers to begin to experiment with training language functionally (Hart & Risley, 1980; Schiefelbusch, 1980) and expressively, as suggested in Skinner's (1957) functional analysis of verbal behavior and Stokes and Bear's (1977) study of generalization. Functional analysis of verbal behavior has shown some improvement in the teaching of verbal skills over task analysis of teaching social skills, when skills are used in the natural contexts of social interaction (Clay, 1997).

Skinner (1957) identified several independent function of verbal behavior. Training language to these functions in the natural context reduces the need for mass trials, producing language products that are more fluid, spontaneous, and naturally flow (Clay, 1997). Skinner proposed roughly naming (tacting) was different from requesting (manding) and these were different from discourse (intraverbal) and relations (autoclitics). These functions have received some research showing independence (Twyman, 1996; Partington & Bailey, 1993; Hall & Sundberg, 1987; Lammarre & Holland, 1985). Skinner proposed that speaker behavior (expressive language) was learned differently from listener behavior (receptive language). Research clearly shows functions do not automatically transfer from speaker behavior (expressive language) to listener behavior (receptive language). Thus they could learn them independently (Guess, 1969; Miller, Cuvo, & Borakove, 1977; Keller & Bucher, 1979; Cuvo & Riva, 1980; Lee, 1981; Lee & Pegler, 1982; McIvane, Bass, O'Brien, Grovac, & Stoddard, 1984; Connell, 1986; Goldstein & Brown, 1989; Goldstein & Mousetis, 1989), which Skinner (1957) predicted. Also, expressive language generalizes more than receptive (Goldstein, 1993). Even when training in a receptive modality, expressive language may precede receptive (Goldstein & Brown, 1989).

Carr and Durand (1985) initially proposed a functional account of verbal behavior in the intervention and treatment of severe disruptive behavior. After Carr and Durand (1985) showed that two children with autism displayed increased disruption when adult attention was low, they successfully trained these two children in specific communication skills to get adult attention and reduced disruptive behavior. However, even before this publication Donnellan, Mirenda, Mosaros & Fassbender (1984) extended, applied behavior analysis and therapy techniques to the communicative aspects of some autistic children's aggressive behavior. According to these researchers, children with autism's inability to communicate in a positive, socially appropriate manner may cause many of their tantrums and disruptions. In using a functional analysis methodology, Donnellan et al. described a case of a twelve-year-old boy with autism. The autism was complicated with the diagnosis of moderate retardation. The chief complaint of the parents was the child's tantrums. This prevented them from taking the child into the community.

A functional analysis showed noise from the crowds was an establishing operation for tantrums. Therapists trained the child to express being overwhelmed by the crowd. Upon his request to escape the crowds, the parents gave the child a Walkman to reduce the noise from the crowds. Over time, they reported that the child steadily needed the headset less and less. This was one of the first studies in neutralizing routines.

Given the problem of mutism in autism, over the years, behavior therapists have developed augmentative communication systems. These systems are often based on early work done with primates (Premack, 1976; Rambaugh, 1977) and are called selection-based systems of verbal behavior (Potter, Micheal, & Huber, 1997; Potter, Brown, & Huber, 1997). Selection-based systems serve effectively as a form of augmentative communication (Shafer, 1993). Considerable literature compares selection-based systems to more topography based verbal behavior systems such as sign language (Atkins &Axelrod, 2001; Potter, Brown, & Huber, 1997). One problem with selection based verbal behavior is interaction involved during the process (Potter, Brown, & Huber, 1997). One system that appears not to have this problem, or at least less of it, is the Picture Exchange Communication System (PECS- Bondy & Frost, 1993, 1994). The system requires giving a picture of a desired item to a communicative partner in exchange for the item. This allows the communication act to be complete within a social context. PECS effectively teaches language (Bondy, 2001; Bondy & Frost, 1993).

Milieu Language Training Model

The milieu language-training model (Hart & Rogers-Warren, 1978) is a naturalistic, conversation-based teaching procedure. It functions much like a least to most prompting system. The child's interest in the environment is used as a basis for eliciting and elaborated the child's communication responses (Kaiser, Hendrickson, & Alpert, 1991). It evolved from the incidental teaching model (Hart & Risely, 1975, 1982), which they developed for language-delayed children. One of the milieus teaching model's key ideas are context is more than the who, what, and when. It includes things like the setting and the history of the verbal and linguistic interactions (Warren, 1988). There are five milieu-teaching strategies shown to be effective in teaching new language skills to children with autism. These are incidental teaching, mand-modeling, time delay technique, child cued modeling, and contingent imitation.

Incidental teaching (teaching elaborated language in response to the child's requests) is the primary strategy emphasized in this component of the intervention. In incidental teaching therapists arrange the context to maximize the chances that the child will emit a desired response. When the child emits the response, the therapist shapes and reinforces the response by natural means. For example if a child mands for an apple the therapist reinforces the request by giving the apple. Unlike discrete trial training, incidental strategies are free operant procedures.

Hart and Risely (1975, 1982) developed incidental teaching from the growing literature on generalization (see Stokes & Baer, 1977). The goal of the program was to increase spontaneous speech (Hart & Risely, 1975, 1982). Charlop, Schreibman, and Thiboeau (1985) define spontaneous speech as "verbal response in the absence of a verbal discriminative stimulus" (p. 156). Incidental teaching uses four basic techniques (Haring, Neetz, Lovinger, Peck, et al, 1987): (1) student choice of activity or objects; (2) blocking access to material or event; (3) placing desired material out of reach; (4) offering students the opportunity to use existing communication skills so such skills can be elaborated or shaped. Thus, in contrast to discrete trial, language in incidental teaching is learned expressively and in the natural context. When used with traditional discrete trail training, incidental teaching facilitates generalization (McGee, Krantz, Mason, & McClannahan, 1983). Also, incidental teaching is superior in acquisition and generalization to discrete trial training in language training (McGee, Krantz, & McClannahan, 1985) and social skills (Farmer-Dougan, 1994). Evaluations of incidental teaching procedures find it effective in many areas (Warren & Kaiser, 1986, 1988).

Some consider incidental teaching a "catch them being good" strategy, where we relegate the therapist to the role of waiting for the behavior to occur before reinforcing it. Yet for more skilled therapists incidental teaching is an active technique in which the therapist uses his or her knowledge of behavior to design the context so that a high probability exists that this context will generate the emission of the behavior (Allen & Hart, 1984). Incidental teaching is using all of ones skills as a behavioral engineer. It is important for the behavior therapist to create and capitalize on routines that can help in the expressive use of language (Yoder & Davis, 1992; Yoder, Davis, & Bishop, 1992). The behavior therapists need to design ways that the context, some suggest a greater understanding of momentary aspects that change the value of reinforcers called establishing operations would be helpful (Shafer, 1994). Much research is needed in this area.

Behavior therapists use and teach parents prompting techniques: child-cued modeling, mand-modeling, and time-delay techniques. Child cued modeling refers to responses to child initiations (Warren & Kaiser, 1986). Conversational style is taught through child-cued modeling and mand-modeling. Mand-modeling (Warren & Bambara, 1989) is a technique that uses mands to prompt child action and modeling to enhance production. It follows the least to most prompting guidelines (Mosk & Bucher, 1984). Mands should always be targeted, clear, and follow the child's attentional leads (Yoder & Warren, 1993). Mands following attentional leads of the child are show to elaborate children's vocabulary and to be positively correlated with later linguistic growth (Warren & Yoder, 1998)

Since some mands may be difficult for children to understand (Yoder & Warren, 1993), Halle, Baer, and Spradlin (1981) developed the time delay procedure. In a time delay procedure this uses the least amount of prompting since it is using a pause, waiting for the child to respond. They designed this procedure gives the child an opportunity to respond (Greenwood, Hart, Walker, & Risely, 1994). Greenwood and colleagues (1994) trained teachers to delay five seconds before offering assistance or providing materials during play activities including free play and lunch. A child's failure to respond resulted in teacher modeling correct responses. Time delay increased spontaneous requests for assistance (Matson, Sevin, Fridley, & Love, 1990). This was replicated by Charlop et al. (1985) and Gobbi, Cipani, Hudson, and Lapenta-Neudeck (1986) and replicated in severely autistic children (Charlop & Trasowech, 1991). Time delay was as effective in developing "self-initiated" verbalization as a treatment package consisting of verbal modeling, visual cues, fading techniques, and training with multiple exemplars (Matson, Sevin, Box, Francis, et al., 1993).

Contingent imitation is another technique used to enhance language skills (Yoder & Warren, 1993). In contingent imitation therapists or parents follow the child's lead and imitate the lead. For example if the child expresses a sound the adult will echo that sound once or even several times. Also the adult might add variation to the sounds. Contingent imitation has not received much study.

Mand-modeling is a combination of two techniques. The first technique is manding. After the time delay, the therapist will prompt “what do you want?” This mand may evoke the response from the child. (e.g., “candy”). At this point giving him the candy would reinforce the child’s mand. If this does not succeed, then you would go to the next level of prompting, which is modeling. The therapist would place the child’s hand on the object and model “you want candy” and wait for the child to echo the response. After the child repeats the model, s/he would be reinforced with the object (candy).

Behavior therapists find milieu training easy to teach to parents (Alpert & Kaiser, 1992). Alpert and Kaiser (1992) showed that all of the six mothers in their study trained quickly, developing the skills of incidental teaching, mand-modeling, and time-delay techniques. These skills generalized to two untrained situations. The parents displayed skills on three months follow probes. The effects of milieu training on treatment protocols for autism are just now beginning to be realized and will have considerable impact on the field in the future. However, no long-term follow-up studies exist showing incidental teaching has the developmental impact of discrete trial training. Thus longitudinal designs are needed. Longitudinal designs do exist showing the acquisition of language and have been employed in the research of Hart and Risely (1995).

Parent Training

In the Lovaas (1987) study, a greater emphasis on parent training occurred. Behavioral parent training is an integral part of the treatment (Handleman & Harris, 1986). The most common form of parent training involves teaching parents the discrete trial format (Schreibman, Kaneko, & Koegel, 1991; Lovaas, 1978). The program teaches parents to provide clear instructions, use prompts, provide reinforcers for correct responses on a trial-by-trial basis (e.g., Schreiberman & Koegel, 1981; Lovaas, 1978). Parent training has a major impact in cost effectiveness of a program. Keogel, Screiberman, Britten, Buckley, & O’Neill (1982) showed thirty hours of parent training, was superior to 200 hours of direct treatment.

In the last fifteen years parent training procedures have changed to reflect more of the natural language training like incidental teaching or pivotal response training (Schreibman, Kaneko, & Koegel, 1991). Parents readily learn procedures for incidental teaching of children (Alpert & Kaiser, 1992). Pivotal response training focuses on motivational variables and multiple environmental cues during the training to promote generalization and more fluent language use. Schreibman and colleagues (1991) showed parents prefer the natural language procedures to the discrete trial format. A behavior specialist should take this into account.

FUTURE DIRECTIONS

Recombinative Generalization

An area of future interest is work in recombinative generalization (Goldstein, 1983, 1985, 1993). This work draws on work by behavioral psycholinguist Esper (1925, 1973) who organized artificial linguistic systems into matrices. He assigned two word nonsense combinations to color shapes and taught them to adults. Esper (1973) proposed through analogy adults learn responds to untrained shapes. This research, as Whetherby (1978) demonstrated, lead to insights into Skinner’s (1957) autoclitic frames:

> *"Something less than full-fledged relational autoclitic behavior is involved when partially conditioned autoclitic 'frames' combine with responses appropriate to specific situations. Having responded to many pairs of objects with behavior such as the hat and the shoe and the gun and the hat, the speaker may make the response the boy and the bicycle on a novel occasion. If he has acquired a series of responses such as the boy's gun, the boy's shoe, and the boy's hat, we may suppose that the partial frame the boy's ______ is available for recombination with other responses. The first time the boy acquires a bicycle, the speaker can compose a new unit the boy's bicycle. This is not simply the emission of two responses separately acquired. The process resembles the multiple causation of Chapter 9. The*

relational aspects of the situation strengthen a frame, and specific features of the situation strengthen the responses fitted into it."(Skinner, 1957, p. 336)

Using an object-location matrix, persons with severe retardation through training of four basic elements to establish the frame, generalized to more than forty-nine new combinations (Goldstein & Mousetis, 1989). Also, given four expressive combinations of object-preposition-location, ninety untrained responses emerged (Goldstein & Mousetis, 1989). This technique offers hope for the future of language training in retardation and autism. Mineo and Goldstein (1990) efectively used matrix training procedures to teach action and object utterances. In this study developmentally delayed preschoolers were able to generalize 48 receptive and 48 expressive responses from only 4 to 6 direct teachings.

Stimulus Equivalence Training

One of the most important contributions to behavior analysis over the last thirty years has been the study of equivalence relations. In the standard equivalence training paradigm if A being trained to B and B is trained to C then if a subject is shown C and responds with A, than equivalence has occurred (Sidman & Cressons, 1973). Equivalence relations might represent a broader category of arbitrary relational responding in humans (Barnes, Hegarty & Smeet, 1997; Hayes, 1994) and approximates what is termed "symbolic." Equivalence training may ease transfer of function across modalities of speaker and listener behavior (Sidman & Cressons, 1973; Goldstein, 1993). Still, more research is needed in this area to determine ways to integrate the procedures directly into curriculum (McIvlane, Dube, Greene, & Serna, 1993).

Scripted Interaction

The problem of prompt dependency and failure of response variations is common in autistic treatments. Krantz and McClannahan (1993) used a scripting procedure to increase the variability of conversation. In this procedure they introduced and then faded ten scripts to least prompts. This procedure led to greater generalization, increased recombinative elements, and more generative language. These benefits contribute to fluency leading children to spend more time interacting with adults (Krantz & McClannahan, 1998). In addition, they utilized a combination of script fading with incidental procedures to expand and elaborate children's language use.

CONCLUSION

The field of autism is rich in behavioral technology and theoretical developments. Behavior analysis is the most productive line of research in autism continuing to refine and enhance techniques. Most notably was the development of discrete trial training, which proved that we can change the developmental course of autism. Still, discrete trial training could benefit from continued research in moderator variables for prompting strategies and the use of more naturalistic techniques to enhance generalization. Areas that will become ever more productive to behavior analysts will be areas that focus on theoretical models of language training such as Skinner (1957) and Esper (1973). These areas will lead us into a new century of research, one that hopefully will see the end to the devastating effects of this disorder.

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