GENERALIZATION OF COMPUTER-ASSISTED ATTENTION TRAINING FOR CHILDREN WITH ATTENTION DEFICIT DISORDER

By

STEVEN ARTHUR MORTON

Bachelor of Arts
Yale University
New Haven, Connecticut
1973

Master of Arts
Duquesne University
Pittsburgh, Pennsylvania
1977

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1985

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
DOCTOR OF PHILOSOPHY
July, 1988

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Thesis Approved:

Kenneth D. Sandvold

Thesis Advisor

Daniel W. McNeil, Ph.D.

J. Barbara Wilkinson

Paula Doutt

Norman N. Durham

Dean of the Graduate College

PREFACE

This study used a multiple baseline across subjects single case design with four experimental subjects aged 10 to 11 years. An attempt was made to improve performance on math problems and to generalize this improvement to a different setting--a summer school classroom--and to both related and unrelated tasks. A treatment package, including (a) a computer math game, (b) computer-assisted cognitive training, and (c) contingency management using a token system and weekly rewards, was introduced following baseline measurements. Classroom measures, assessing academic performance and on-task behavior, were taken for control subjects as well as the experimental subjects to help identify the extent to which observed effects could be attributed to the training.

For all experimental subjects, improvements were seen in both the accuracy and productivity of math problem-solving during a repeated non-reinforced assessment taken in the training laboratory. Another laboratory measure, a non-academic test of attention deployment, showed noticeable improvements, suggesting generalization of training effects. Some generalization to classroom math performance was observed. No improvements in classroom on-task behavior were observed. An analysis of follow-up data suggested that the combination of the training and the summer school program was successful in improving subjects' math achievement and positively affected their parents' ratings of their behavior.

I wish to thank a number of people who were essential in the completion of this project. I am particularly grateful to my major advisor, Dr. Kenneth Sandvold, whose support, wisdom, and clinical judgment were invaluable from the inception of this study. I am also grateful to the other members of the committee, Dr. Pamela Dorsett, Dr. Daniel McNeil, and Dr. Barbara Wilkinson. In particular, I would like to thank Dr. McNeil for his innovative suggestions, Dr. Dorsett for sharing her expertise in both single case methodology and the procedures used in the direct observation of behavior, and Dr. Wilkinson for her guidance and cooperation without which this project would not have been possible.

The computer program which generated the math problems used in this study was written by my friend and colleague, Kevin Robertson. I am grateful to Kevin, and also to Craige Baird for his assistance in writing the computer programs used in the cognitive training.

The computer math games used during the training were Stickybear Math and Stickybear Math 2, written by Richard Hefter and Susan Dubicki, published by Optimum Resource, Inc., and distributed by Weekly Reader Family Software, a division of Xerox Education Publications. My thanks to Dr. Scott Lindgren from whom I purchased the Continuous Performance Task software packages, and to Dr. Phillip Kendall for his permission to use the Self-Control Rating Scale. The tapes used for cueing the observation and recording of classroom behavior were created using the Cricket! clock and speech synthesizer distributed by Street Electronics Corporation.

I would like to thank several undergraduate students who took part in this project. The trainers were Lori Breedlove, Patrick Britt, Mary

Justus, and Gia Niemeyer. The observers in the classroom were Karen Le Blanc, David Blohm, Stacy Boyles, James Lowden, Akin Tunde Morakinoro, Kevin Unrue, and Lesie Warren. Mike Harris assisted with the academic performance assessments in the classroom. Each of the above aided in an initial tabulation of parts of the data. I am grateful to Carolyn Gang for her coordination of the recruitment of undergraduate volunteers. I would also like to thank the graduate student teachers at the summer school program, the home school teachers, and the parents of the youngsters for their interest in and support of this research.

I owe a special debt of thanks to all the children involved in this study, especially to the four boys who participated in the attention training. I enjoyed our collaboration and appreciate their hours of work. I hope they each received some benefit in return.

My family deserves my deepest appreciation. I am grateful to my parents, Robert Morton and Grace Morton, for their financial assistance during my work on this project. I thank my wife, Kathi, for her unfailing encouragement, understanding, and support, and my sons, Daniel and Ben, for their patience and interest in my work.

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CHAPTER I

INTRODUCTION

Under a variety of diagnostic names, attention deficit disordered (A.D.D.) children have experienced difficulties at home and in the school for many years. While they are typically of average or above average intelligence, their inability to organize and sustain attention or to inhibit impulsive responding (Douglas & Peters, 1979) predisposes them to behavior problems and lack of success in school. The extent to which this dysfunction can be corrected is an empirical question. The answer will vary individually depending on the child's cognitive, affective, and environmental resources.

Studies on the effectiveness of treatments for A.D.D. vary along several dimensions. Some of the most important of these dimensions can be defined by answering the following questions: (a) are the subjects medicated, (b) are the target behaviors directly assessed or is improvement inferred from laboratory measures and standardized tests, (c) if reinforcement strategies are used, are the measured behaviors reinforced directly in the natural environment or are reinforcers used strictly to enhance performance during training in a laboratory setting, (d) is on-task behavior assessed only by rating scales or are behavioral observation procedures used, (e) are academic measures taken in addition to measures of on-task behavior, (f) is an effort made to show if effects generalized to a naturalistic setting, and (g) how durable are the effects?

Psychostimulant medication has long been the most frequently used form of treatment for children with A.D.D. (Horn, Chatoor, & Connors, 1983). In recent years, however, these children have been successfully treated using behavioral contingency management techniques. Several studies have been conducted in the last ten years comparing the effects of the two treatment approaches (e.g., Ayllon, Layman, & Kandel, 1975; Pelham, 1977; Rapport, Murphy, & Bailey, 1982; Shafto & Sulzbacher, 1977; Walbert & Dries, 1977; Williamson, Calpin, DiLorenzo, Garris, & Petti, 1981). In these studies, contingency management procedures repeatedly have been shown to equal or surpass the control that medications exert over disruptive or off-task behavior. As well, medications have rarely demonstrated improvements on academic measures, while direct reinforcement of academic performance has consistently been able to occasion increases in measures such as percent of assignments completed and percent correct.

There are limitations associated with the contingency management approach. Specific target behaviors require fairly specific contingency procedures as there is little generalization across behaviors (Ferritor, Buckholdt, Hamblin, & Smith, 1972). As well, in order to enhance the durability of effects, the treatment must target behaviors which will be reinforced by a system of naturally occurring consequences which can take over as the contingency management system is faded. The existence of such a system, reinforcing academic performance and on-task behavior in the natural environment, cannot always be assured. Also, techniques such as those used in the Ayllon et al. (1975) and the Shafto and Sulzbacher (1977) studies require that the teacher be mobile within the classroom to administer reinforcements, which may distract other students and consume too much time. These limitations have resulted in a reluctance to use behavioral techniques in the classroom. Even when taking these factors into consideration, the behavioral approach has the distinct advantage of being substantiated with an ever-increasing body of empirical research. Research such as that done by Rapport, Murphy, and Bailey (1980, 1982) is attempting to introduce reinforcement techniques which will be less obtrusive and, therefore, more attractive to the classroom teacher.

An increase in appreciation for the role cognitive factors play in learning and social behavior (Konstantareas & Homatidis, 1983) has led several clinicians to train A.D.D. children to improve cognitive mediation skills. This usually involves teaching children to self-instruct, i.e., "to talk to themselves" through the course of following a stepwise problem solving strategy (Meichenbaum & Goodman, 1971). Research on this approach has shown mixed success at improving scores on laboratory tests. Generalization of the effects of cognitive training to the classroom has occurred only when training performance has been reinforced with tangible rewards (Bornstein & Quevillon, 1976; Cameron & Robinson, 1980; Kendall & Zupan, 1981).

With cognitive training requiring the use of reinforcement techniques in order for it to successfully generalize to a classroom setting, the question can be asked, "What advantage is there to cognitive training at all?" The answer lies in the criticisms of the contingency management approach with A.D.D. children, i.e., that it is unwieldy and obtrusive, that it rarely generalizes to other behaviors or settings, and that its effects do not endure. The advantage of the combined cognitive-behavioral approach as it is most frequently implemented in research efforts is that it is implemented outside the classroom, leaving other students undisturbed and the teacher freer to conduct the business of instruction, while its positive effects are seen in the classroom (Bornstein & Quevillon, 1976; Cameron & Robinson, 1980; Kendall & Zupan, 1981). Cognitive training has been shown to generalize across behaviors (Cameron & Robinson, 1980; Kendall & Wilcox, 1980). When combined with contingency management it has shown maintenance of effects not seen with contingency management alone (Kendall & Braswell, 1982).

In the cognitive-behavioral approach the component relationship of the cognitive self-instructional training and the behavioral reinforcement of performance during training is usually discussed in terms of the behavioral component strengthening the effects of the cognitive training. In other words, the reinforcement is seen as increasing the incentive of the child to participate in the cognitive training. It is also possible, however, to see the cognitive component as facilitating the generalization of effects attributable to the contingency management program. That is to say, the cognitive training helps the child to replace the external management of contingencies with an internal system of rewards using self-praise. No experiments attempting to determine the relative roles of the components of cognitive-behavioral training have been reported. The present study may contribute to an understanding of this relationship as it uses separate reinforcement and cognitive training components, without providing reinforcement as a part of the cognitive training.

The intent of the present study was to investigate the generalization effects of combined cognitive-behavioral programming outside class on two types of classroom behavior, task-attending and academic performance. Termed attention training because of the focus on training subjects to successfully attend to academic problems, the treatment had three components: (a) a microcomputer interactional software program, with immediate reinforcement for academic performance, (b) token reinforcement for performance on math worksheets, and (c) cognitive self-instructional training using math problems. Though scholastic training programs available for use with microcomputers have proliferated in the last few years, little is known about whether or not such training devices, when coupled with a reinforcement schedule, can be helpful in improving the A.D.D. child's deployment of attention to academic tasks.

While contingency management techniques with the A.D.D. child have been unable to show response generalization beyond immediately targeted behaviors, there is an empirical basis for concluding that the additive effects of this approach with cognitive training are successful in generalizing training effects beyond immediately reinforced behaviors. The academic measures targeted for reinforcement in the training lab of this study were expected to show distinct improvement with treatment. Less improvement was expected for nonreinforced academic measures given in the training laboratory. Still less improvement was predicted on academic measures in a classroom. If the treatment was to be considered successful, however, the in-class measures, including observations of on-task behavior, needed to show measurable generalization of the treatment effects. A test of attention was given as an additional repeated measure to show that positive effects resulted from improvements in attention deployment and not from practice. Pre- and post-training administrations of a behavior rating scale and of relevant subtests of a standardized test of achievement were given to test for response maintenance.

CHAPTER II

REVIEW OF LITERATURE

The diagnosis of Attention Deficit Disorder did not appear in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1980) until the third edition (DSM-III), published in 1980. According to the DSM-III, "the essential features [of the disorder] are signs of developmentally inappropriate inattention and impulsivity" (p. 41), while developmentally inappropriate hyperactivity may or may not be present.

Prior to 1980, research on the disorder used a variety of labels. These still remain in use and in some cases, as with the term learning disability, the diagnosis of A.D.D. cannot be used interchangeably with the prior nomenclature. While evidence of inattention, poor impulse control, hyperactivity, and learning problems appear simultaneously in many children, children diagnosed as hyperactive cannot always be shown to have a learning disability (Hoy, Weiss, Minde, & Cohen, 1978). Attentional difficulties, on the other hand, are being seen increasingly by researchers in education as crucial to the problems of the learning disabled child (e.g., Dykman, Akerman, Clements, & Peters, 1971; Keogh & Margolis, 1976; Lerner, 1981; Ross, 1976).

Before the publication of the DSM-III, psychological research in the area focused primarily on hyperactive behavior. This was likely to have been attributable to the fact that, when it is present, hyperactivity is the most salient aspect of the disorder. The DSM-II did not even provide nosology for the disorder without the presence of hyperactive behavior. In contrast, Virginia Douglas and co-workers (Douglas, 1972, 1974, 1976; Douglas & Peters, 1979) have long argued that the primary limitation of hyperactive children is "an inability to sustain attention and to inhibit impulsive responding on tasks or in social situations that require focused, reflective, organized, and self-directed effort" (Douglas & Peters, 1979, p.173). The DSM-III now gives prominence to the attentional difficulties associated with this disorder, pointing out that while the excess motor activity of the A.D.D. child often diminishes during adolescence, impaired attention frequently does not (American Psychiatric Association, 1980).

After providing a background for the discussion, this chapter will review the various approaches to intervening in childhood A.D.D., citing studies which have attempted to test the efficacy of an approach. Particular attention will be given to the few studies which have attempted to compare the effectiveness of two different approaches. Because the A.D.D. name for the disorder is fairly recent, relevant research in the area exists under other names as well. This research will also be cited if subject selection was based on evidence of problems of attention, impulse control, or quality of activity.

Background Information

A.D.D., 10 times more common among boys than among girls (American Psychiatric Association, 1980), can be diagnosed with or without symptoms of hyperactivity. The rate of its prevalence without hyperactivity is uncertain (Kendall & Braswell, 1985).

Considerable disparities have been found in estimates of the occurrence of hyperactivity across national boundaries. Rutter and his associates have made one comparison showing 0.1 percent occurrence among children on the Isle of Wight (Rutter, Tizard, & Whitmore, 1970) and one to two percent of the child clinic population in the United Kingdom (Rutter, Schaffer, & Shepherd, 1975, cited in Sandberg, 1981). This stands in contrast to a rate of from 4 to 10 percent of school-aged children in the U.S. (Sandberg, Rutter, & Taylor, 1978).

One or two children in almost every classroom in the the United States is considered to be hyperactive (Whalen & Henker, 1980). In their 1975 study, Kahn and Gardner (cited in Safer & Allen, 1976) showed that from 30 to 40 percent of all children referred to mental health clinics in North America were given the diagnosis of hyperactivity. Such statistics have led some authors (e.g., Fish, 1969, 1975; Gittleman, 1981; Sandberg, 1981) to conclude that mental heath professionals in the U.S. are too ready to diagnose the hyperactive syndrome when presented with a few of its behavioral components. This argument is particularly convincing when diagnostic over-inclusiveness has been shown to exist for the identification of another syndrome (schizophrenia) in the U.S., compared to standards used in the U.K. (Cooper et al., 1972).

Some authors (e.g., Quay, Routh, & Shapiro, 1987; Rubinstein & Brown, 1984) have questioned whether or not an A.D.D. syndrome exists at all. Three major human services disciplines, however, have pursued the difficult questions of how to treat children with the pattern of disturbed behaviors identified in the DSM-III as A.D.D. Education, psychology, and medicine, using differing terminologies, each have a tradition of proposing frameworks for understanding and intervening in this disorder. Historically, of the three, medicine has been more active in attempting to determine an etiology, primarily putting forward an explanation based on an assumption of neurological impairment. Education and psychology have focused more on a concern for how to respond to these children in the variety of settings in which they are encountered. With the recent advances in theories of cognition, a common ground is being explored, with work being done to investigate deficiencies in disordered children's learning processes (Kinsbourne & Caplan, 1979), in their attentional processes (Peters, cited in Douglas & Peters, 1979; Routh, 1980), in their decisional processes (Kendall & Braswell, 1982), and in those physiological functions which influence cognitive control (Posner & Boies, 1971; Pribram & McGuiness, 1975; and Zentall, 1975).

While many have attempted to explain the etiology the syndrome (e.g. Safer & Allen, 1976), the answer has been elusive. Separate attempts to explain the presence of this pattern and identify primary aspects have spawned a variety of diagnostic and etiological approaches. Behavior patterns which are almost identical to A.D.D. in their configuration and onset of occurrence have gone under a variety of names. Prior to the appearance of the DSM-III this diagnostic group was primarily identified by three types of terms, depending on the professional context of the discussion: (a) learning disability or learning disorder; (b) hyperactivity, hyperkinetic reaction or syndrome, or hyperkinetic-impulsive disorder; and (c) minimal brain dysfunction, minimal cerebral dysfunction, or central processing dysfunction (Chalfant & Scheffelin, (1969). According to Shain (1977), the terms are "interchangeable from a practical, clinical point of view" (p. 25) even if the theoretical perspectives from which they derive differ. He stated: "Learning disorders is an educational concept; hyperactive behavior disorders is a behavioral, psychiatric concept; and minimal brain dysfunction is a neurological concept. They all refer to the same large group of children" (Shain, 1977, p. 25).

Shain's position may be overstated. While the presence of abnormal neurological functioning in the learning disabled or hyperactive child is rarely doubted, studies establishing adequate criteria for the use of neurological signs in establishing the MBD diagnosis have not been forthcoming. As discussed in a following section on MBD, the value of MBD as a diagnostic entity has come under a great deal of criticism.

If one concentrates on the diagnoses of learning disability and hyperactivity, neither diagnosis has been shown to include all phenomena associated with the other. Most hyperactive children do poorly in school (Minde et al., 1971), but experiments designed to identify specific learning disabilities for hyperactive children have failed to provide unequivocal results (Douglas, 1972; Hoy et al., 1978). The DSM-III has provided for separate diagnoses of specific developmental disorders independent of the A.D.D. diagnosis, e.g., developmental reading disorder and developmental arithmetic disorder. As Douglas and Peters (1979) put it:

> Thus, in diagnosing a child, it becomes important to make separate and independent decisions about the appropriateness of applying the hyperactivity and learning-disability label. This does not mean, of course, that a particular child could not be both learning-disabled and hyperactive; we are simply arguing that separate judgments be made on the basis of empirical evidence. (p. 176)

In dealing with the group of problems now known as A.D.D., it is vital to recognize the heterogeneity of symptoms contained in the label and to avoid assuming that a child diagnosed as A.D.D. displays all its behaviors. Specificity in diagnosis, always an important endeavor, is essential in the diagnosis of A.D.D. because of this heterogeneity. For this same reason, the devising of a suitable plan of treatment must be highly individualized. Just as the deficits of the disorder are uniquely configured for each individual, so should the course of treatment remain responsive to progressively defined, individual needs.

History of the Diagnosis

Learning Disability

With the early work on the reading problems of adults with aphasia came the recognition that poor school performance was not necessarily a sign of low intelligence. The term dyslexia was first proposed in 1887 by Berlin (cited in Nichols & Chen, 1981) to describe a variant of aphasia typified by a radically reduced ability to read. Hinshelwood (1895), an opthalmologist, wrote a letter to Lancet eight years later titled, "Word blindness and visual memory" prompting Morgan (1896), also an opthalmologist, to report his case of an intelligent 14-year-old who appeared incapable of learning to read. These early workers surmised that the limitations they observed were attributable to congenital rather than acquired abnormalities, with Hinshelwood (1917) going on to claim that cerebral lesions were involved. By then, Still (1902) had already lectured about children showing poor self-control and overactivity, labeling the pattern a defect in "moral control".

The first psychologist to contribute directly to this discussion was Bronner (1917) who regarded reading disabilities as comparable to sensory and motor impairments. Others (Gray, 1925; Hollingsworth, 1923) argued for recognition of additional potential causes of "reading retardation" beyond actual tissue damage. These factors included poor health, malnutrition, auditory and visual defects, inappropriate methods of instruction, poor school attendance and nationality.

Summarizing 10 years of research in the area in a widely cited book, Reading, Writing, and Speech Problems in Children, Orton (1937), a physician, attempted to integrate the educational and neurological perspectives. He was an early proponent of the "lack of dominance" theory which purported to explain mirror writing and letter reversals by a failure of either cerebral hemisphere to establish functional dominance. His theoretical work led to the development of the Gillingham teaching method (Lerner, 1981). Generally, however, educational psychologists de-emphasized neurological factors, focusing instead on general health and on social and emotional adjustment (e.g., Robinson, 1946).

By the 1950's researchers (e.g., Hermann, 1959) began to distinguish between primary reading retardation (dyslexia) and poor reading resulting from ill health or psychological disturbance. Rabinovitch, Drew, DeJong, Ingram, and Withey (1954) argued that appropriate differentiation between primary and secondary reading retardation would eliminate the confusion which continued regarding the etiology, diagnosis, and treatment of the problem. Researchers such as Kawi and Pasamanick (1958, 1959) attempted to attribute the cause of the primary defect to minimal brain damage, noting a high incidence of prenatal complications in children with reading problems.

As did other professionals, educators became dissatisfied with the entirely inferential method by which children became labeled "minimally brain damaged" and began looking for other, more descriptive terms. Kirk (1963), one of the first to use the new term, suggested that "learning disabled" best described the difficulties the child experienced while remaining neutral on the unsettled questions of causality. In contrast to other entries in the sprawling nomenclature generated in this field, the term "learning disability" has been used consistently by one of the involved professions (education) for over 20 years and has enjoyed wide use by other professions.

Hyperactivity

In what has become a hallmark chapter on hyperactivity, Douglas and Peters (1979) concluded that most of the limitations that define the hyperactive syndrome result from deficiencies in three related processes: 1) the investment of attention and effort; 2) the inhibition of impulsive responding; and 3) the modulation of arousal level to meet situational or task demands. In contrast to some authors who attempted to establish one of these processes as central to the hyperactive child's disabilities (e.g., Keogh, 1971; Ross, 1976), Douglas and Peters (1979) proposed that all three process-disturbances are primary and interrelated in the behavior of the hyperactive child.

Barkley (1981), in his widely quoted book, Hyperactive Children, also identified distractibility, inattention, and impulsivity as key components of hyperactivity. Pointing to its early predictors and "multiple etiologies" (p. 48), he described the developmental course of hyperactivity. Though he was unable to cite research identifying the prognostic impact of environmental factors, Barkley (1976) increased professional attention to the importance of psychosocial, especially familial, influences on adolescent and adult adjustment. Citing the complexity of the syndrome, he called for treatment approaches that address a wide range of problems.

Minimal Brain Dysfunction

The current concept of brain dysfunction has its roots in the "organic psychiatry" of the late nineteenth century when language disorders, along with all psychiatric disorders, were seen as organic in etiology (Strother, 1973). Largely due to the impact of Freud and the psychoanalytic movement, the assumption that disturbed behavior and emotions were of a psychogenic etiology predominated in the early twentieth century (Gardner, 1979).

With the observation of behavioral and cognitive sequelae in children suffering from brain trauma or infection, the diagnostic focus shifted to the concept of "brain damage". Though intellectual functioning appeared to be left intact in many cases, impulsivity, hyperactivity, emotional lability, and antisocial behavior were demonstrably increased for postencephalic children (Ebaugh, 1923) and for some children with perinatal brain insults (Doll, Phelps, & Melcher, 1932). Lord (1937) noted a variety of similar psychological disturbances accompanying childhood cerebral palsy. Introducing the term "brain-damaged", Strauss and his associates were able to predict histories of cerebral insults from the presence of hyperactivity, perceptual impairment, and other abnormal traits (Werner & Strauss, 1941). Subsequent to these findings, the term brain-damaged began being used to describe the condition of any child who showed dysfunctions similar to the behavioral and learning dysfunctions of children for whom structural lesions were in fact identified. A child exhibiting characteristics similar to those of brain damaged children was assumed to be a victim of brain damage, even when the child's history did not bear this out (Black, 1981).

Recognizing that organicity resulted in a range of severity of impairment, Strauss and Lehtinen (1947) introduced the term "minimal brain damage" to describe milder conditions of organic involvement. This concept was accepted for a number of years and was applied to a variety of behavioral and learning problems. The illogic behind this assumption--that since the minimally brain damaged are hyperactive than damage must have occurred to the brains of hyperactives--led some (e.g., Birch, 1964) to rethink the designation minimally brain damaged. Stevens and Birch (1957) recommended the term "Strauss syndrome" focusing on the occurrence of combinations of behaviors from among the following:

1. erratic and inappropriate behavior on mild provocation
2. increased motor activity disproportionate to the stimulus
3. poor organization of behavior
4. distractibility of more than ordinary degree under ordinary conditions
5. persistent faulty perceptions
6. persistent hyperactivity
7. awkwardness and consistently poor motor performance

In 1966 Clements' (1966) review of the literature showed that at least thirty-eight different terms were in use at that time, all attempting to identify children with similar behaviors. Favoring the cause-related terms which focused on "organic aspects" over the behavior-related terms which focused on "consequences," Clements (1966) suggested the term Minimal Brain Dysfunction in an attempt to consolidate terms. He avoided use of the terms "brain-injured" and "brain damaged" as these had proven to have a stigmatizing effect.

Notwithstanding Clements' attempt to end the proliferation of nomenclature in this field, Schain (cited in Small, 1982), in a review of the literature published in 1968, found several frequently used diagnoses which he saw as equivalent to MBD. These included:

1. choreiform syndrome
2. clumsy-child syndrome

3. visual-motor disability
4. hyperkinetic-behavior syndrome
5. developmental Gerstmann's syndrome
6. strephosymbolia
7. specific dyslexia
8. developmental dyslexia
9. congenital word blindness
10. perceptually handicapped
11. primary reading retardation
12. specific language disability

To these, Small (1982) proposed adding the three Attention Deficit Disorders and the six Developmental Disorders of the DSM-III.

Attention Deficit Disorder

As early as 1971 researchers in the area began to argue that diagnostic clarity could be improved with the addition of terms which would focus on the child's limited ability to deploy attention. Dykman, Akerman, Clements, and Peters (1971) proposed the name attentional deficit syndrome to describe the specific learning disabilities they had been studying. The DSM-III attempts to distinguish the Developmental Disorders (such as Developmental Arithmetic Disorder), the Organic Mental Disorders (such as, Organic Personality Syndrome), and Attention Deficit Disorder. The authors of the DSM-III cite Cantwell (1975a, 1975b) as providing evidence of the lack of proof for the assumptions underlying MBD as a diagnosis.

According to Lerner (1981), the switch in the psychiatric community from MBD to A.D.D. represents a shift from an external diagnosis requiring unknown laboratory tests to an internal diagnosis which requires no such test. Lerner (1981) saw this change as bringing the medical diagnosis more in line with current educational thinking, which itself is focusing increasingly on attentional problems (p. 52).

Studies on Single Approaches to Treatment

Medication

Medication is the most widely used form of treatment for the A.D.D. child (Rapport et al., 1982). A variety of drugs have been used, among them dl-amphetamine (Benzedrine) (Bradley & Bowen, 1940), dextroamphetamine (Dexedrine) (Conners, Rothchild, Eisenberg, Schwartz, & Robinson, 1969; Steinberg, Troshinsky, & Steinberg, 1971) which has been widely used for hyperactive children since 1937, levoamphetamine (Arnold, Wender, McClosky, & Synder, 1972), chlordiazepoxide (Zrull, Westman, & Arthur, 1963), amitriptyline (Drakowski, 1965), phenobarbitol (Eisenberg, 1966), chlorpramazine (Thorazine) (Werry, Weiss, Douglas, & Martin, 1966), thioridizine (Mellaril) (Sprague, Barnes, & Werry, 1970), imipramine (Tofranil) (Winsburg, Bialer, & Dupietz, 1972), hydroxizine (Atarax) (Greenberg, Deem, & McMahon, 1972), benztropine (Carman & Tucker, 1973), lithium carbonate (Greenhill, Rieder, & Wender, 1973), deanol (Deaner) (Conners, 1973), caffeine (Huestis, Arnold, & Smeltzer, 1975; Schnackenberg, 1973), methylphenidate (Ritalin) (Gabrys, 1977) which has been used to treat hyperactive children since 1956, and pemoline (Cylert) (Stephens, Pelham, & Skinner, 1984), introduced in the U.S. in 1975.

Side effects to methylphenidate, now the most commonly used medication for A.D.D., have been noted, including anorexia, irritability, insomnia, stomach ache (Millichap, 1973), and even Tourette's syndrome (Dillon, Salzman, & Schulsinger, 1985). Some physicians are, therefore, reluctant to prescribe this drug, especially in the light of evidence that there may be long-term effects on growth and metabolism (Stroufe & Stewart, 1973). Caffeine has been shown by Lehmann (cited in Garfinkle, Webster, & Sloman, 1981) to have the undesirable side effects of tachiacardia, palpitations, and gastrointestinal upset. The other drugs listed above, with the exception of pemoline which has not been extensively studied, have been shown either to be ineffective with prolonged use or to have worse side effects than those associated with methylphenidate.

An area of controversy within the literature on psychostimulant treatment for A.D.D. concerns the phenomenon of state-dependent learning (SDL) which has been demonstrated in some studies. According to Stephens et al. (1984):

> SDL is characterized by an absence or decrement in transfer [of learning] between drugged and nondrugged states, such that information learned in a nondrugged state is not easily retrieved when testing occurs in a drugged condition; likewise, there is a decrement in transfer to the nondrug state when learning takes place in the drugged state. (p. 105)

While Aman and Sprague (1974) and Gan and Cantwell (1982) found no SDL effects from psychostimulant treatment of A.D.D. children, Swanson and Kinsborne (1979) and others (e.g., Wulbert & Dries, 1977) have demonstrated such effects. If SDL does occur with A.D.D. children taking stimulant medication, the result could be considerably disruptive to their educational experience. Swanson, Kinsborne, Roberts, and Zucker (1978) have shown that doses of methylphenidate have a short periods of activity with abrupt declines in learning facilitation. A child taking methylphenidate may move in and out of a drugged state several times during a day. If learning and/or retrieval under the influence of methylphenidate is state-dependent then the child may not be able to efficiently use learned material even within the same day. Ayllon et al. (1975) found that academic performance on math and reading tasks gradually improved following the elimination of longstanding administrations of methylphenidate.

Reviews of experimentation to identify effects of stimulant medication on behavior ratings and on measures of attention (e.g., Cantwell & Carlson, 1978; Hinshaw, Henker, & Whalen, 1984; Safer & Allen, 1976; Swanson & Kinsborne, 1979) have cited numerous studies demonstrating positive results. A number of studies have used standard achievement tests to measure medication treatment effects on academic performance, yielding little success (e.g., Rie, Rie, Stewart, & Ambuel, 1976; Barkley & Cunningham, 1978). A few experiments have attempted to directly investigate the effects of psychostimulants on learning. The relative absence of this focus in the research literature has been criticized (Gadow, 1983; Sprague & Berger, 1980; Stephens et al., 1984) as a significant shortcoming considering that one of the major problems associated with A.D.D. is poor academic performance.

Those few studies which have assessed effects of stimulant medications on learning tasks have resulted in contradictory reports. Although Conners (1966) and Aman and Sprague (1974) found no effect of stimulants on paired associate learning tasks, Swanson et al. (1978)

reported positive effects. Psychostimulants have been shown to enhance performance for short-term memory tasks involving picture recognition (Sprague & Sleator, 1977) and word recall (Weingartner et al., 1980), and for measures of reading comprehension and math performance (Pelham, Bender, Caddell, & Booth, 1982, cited in Stephens et al., 1984). It should be noted that the dosages used in these studies were below the level typically titrated for maximum effect on behavioral measures such as percent of time on task.

Authors who advocate the use of stimulant medication for A.D.D. children have been unable to explain the absence of improvement in the classroom in the majority of studies which collect academic achievement data. While the effect of stimulants on laboratory learning tasks has not been shown conclusively, whatever effects that are seen in the lab are generally not transferred to the classroom setting. As Stephens et al. (1984) pointed out, the determination of the dosage of medication given presents the physician with a choice: does the physician give the higher dosage which may result in improved behavior in the classroom while possibly impeding cognitive functioning (Sleator & Sprague, 1974), or does he or she prescribe a lower dosage which may improve cognitive functions without significantly assisting in behavioral management. Considering that such a choice must be made when using medication with A.D.D. children argues favorably for alternative, or at least additional, treatment approaches. The fact that some of what is learned during a drugged state may not be accessible to the child when the medication clears only magnifies the apparent inadequacy of psychostimulants to fully intervene in A.D.D.

Behavior Modification

In the late 1960s and early 1970s the movement toward applying behavioral principals to clinical problems began to have its effect on research approaches for treatment of what is now called A.D.D. The hyperactivity, impulsivity, and distractibility observed in the A.D.D. child were being seen by behaviorists as the direct targets for change rather than as the symptoms of a disordered personality or a malfunctioning cerebrum. Though they are not as widely used in applied settings as is medication, behavioral approaches have been shown in the research literature to have a clearcut advantage over all other approaches in effecting change when distinct problem behaviors are targeted.

As the school is a primary setting for the occurrence and identification of the dysfunctional behavior associated with A.D.D., much of the behavioral research on this disorder has focused on classroom behavior, primarily on-task behavior. Shemberg, Keeley, Gill, and Garton (1972) have pointed out, however, that strengthening attending behaviors without concurrent improvement in academic performance would not be meaningful to the child's educational experience. The relationship between attending behavior and academic performance has been the subject of much research without a clear generalization becoming evident. Several contingency management studies have shown that when reinforcement is made contingent on improved academic performance, attending behavior shows accompanying increases (Hay, Hay, & Nelson, 1977; Kirby & Shields, 1972; Marholin & Steinman, 1977; Martin & Powers, 1967; Sindelar, Honsaker, & Jenkins, 1982). A study by Ferritor et al. (1972) was unable to produce this effect; this finding has not been replicated, however.

Others have successfully shown that increases in attending behavior have occasioned concurrent improvement in academic performance (Hallahan, Lloyd, Kneedler, & Marshall, 1982; Iwata & Bailey, 1974; Lloyd, Hallahan, Kosiewicz, & Kneedler, 1982; Marholin & Steinman, 1977; Rapport et al., 1980). This finding has been contradicted by other research (Ferritor et al., 1972; Hay et al., 1977; Shemberg et al., 1972). Differences in subject populations, (e.g., the severity of attentional difficulties), in settings, (e.g., the ratio of students to teachers), and in procedures (e.g., the nature of the contingencies used) may account for the contradictions in the literature. Research needs to be done demonstrating what types of interventions are called for with specific types of children in given settings.

Contingency Management. The reinforcement of behavior through management of environmental contingencies has been successfully applied to the problem of A.D.D. behavior using a differential reinforcement of other behavior approach as well as a response cost approach. Rapport et al. (1980) reported a response cost technique to increase both on-task behavior and completion of academic assignments in what the reader could assume was a regular classroom. They used an alternating treatments single case design to study the behavior of a 7-year-old boy recently diagnosed as hyperkinetic. He was told by his teacher that he could earn up to 30 minutes of free-time for "working hard" during one-hour of seat-work on reading, writing, math, and spelling assignments. He was also told that he would lose one minute of free-time every time the teacher looked up and found him not working. On each of the latter occasions the teacher would flip over a card on a spiral bound display and indicate to the subject that he had lost a minute of free-time. The subject was further instructed to look at the teacher's display on occasion and to keep a smaller but similar display on his desk up-to-date. Free-time was awarded on the basis of the number of minutes shown on the teacher's display at the end of the seat-work period.

The Rapport et al. (1980) study used behavioral observation as one of the dependent measures. The hour of seat-work was divided into 120 intervals in which off-task behavior was assessed in a 25-second observe and 5-second record procedure. Off-task behavior was defined as "visual nonattention to one's materials for longer than 2 seconds, unless the student was talking to the teacher (with permission), had his hand raised above his head, or was adjusting the cards attached to his response cost apparatus" (p. 100). No data were provided on the amount of time spent distracted by the counting apparatus. While this definition leaves vague the meaning of "inattention" and relies on the observers' judgment to determine when two seconds had passed, the authors reported adequate agreement between observers.

Two additional measures were used in the Rapport et al. (1980) study as dependent variables: percent of assignments completed, and percent correct for assignments. Following a seven-day period in which baseline stability of observational data was reached, the experimental design alternated group contingencies (where the entire class was awarded the free-time earned by the subject) with individual contingencies on an every other day basis for 14 days. The response cost procedure was then withdrawn and for 15 days the subject was given 30 minutes of free-time only if he completed all assignments during the allotted hour (assignment completion contingency).

Visual inspection of the results of the study showed the effectiveness of the response cost treatments in reducing off-task behavior. This was demonstrated in the observational data by (a) reduced variability of data when compared to baseline, (b) nonoverlap of group contingency data (mean of 16 percent) and individual contingency data (mean of 6 percent), and (c) a marked reduction of off-task behavior for both types of contingency when compared to baseline data (mean of 73 percent). Baseline stability of the two academic measures was established for reading and spelling only. In spelling, performance improved dramatically from zero problems completed to almost all problems completed, with over 80 percent accuracy, during the response cost treatments. Though comparisons to baseline for math and writing tasks were not possible, the data did show that consistently good academic performance accompanied the reduction of off-task behavior for all assignments. The alternating treatments had no apparent differential effect on the academic measures.

Findings such as those reported in the Rapport et al. (1980) study demonstrate the relative independence of attending and academic behaviors. Others have directly reinforced academic performance in the classroom. Studying a learning disabled seven-year-old girl described as highly distractible, Sindelar et al. (1982) used a single case alternating treatments design to look at the comparative effects of two reinforcement procedures: response cost (RC) and differential reinforcement of other behavior (DRO). In a tutorial reading skills situation, the number of words per minute read orally and the number of "lookaways" were measured across five conditions: baseline, DRO_1, RC_1, DRO_2, and RC_2. Phase length varied from four to ten sessions. A lookaway was defined as "any head or eye movement away from the page or the tutor's face, including looking away while apparently 'thinking about' or 'conjuring up' a response" (p. 5). The authors noted that the abacus used to tally points was distracting to the subject, but made no specific recommendations about remediating this problem in treatment situations.

The DRO treatment in the Sindelar et al. (1982) study was essentially a condition of positive reinforcement for academic productivity. The subject was given a token (exchangeable for a variety of reinforcers) if she read a half-page of her assignment without looking away. In the RC condition the subject was given all 12 tokens noncontingently at the beginning of each session, losing a token for the first lookaway on each half-page. The subject was not required to finish the half-pages in order to keep tokens. The results of the experiment showed that both treatment conditions effected clinically significant decreases in lookaways, with the RC condition showing the least fluctuation of scores. The authors concluded on the basis of mean scores for each condition that the RC treatment was more effective than the DRO condition. Visual inspection of the data shows that DRO data had not stabilized prior to changes in conditions; longer phases would have afforded a more comprehensive comparison. Response cost was shown to effect its impact more quickly, though order effects were not controlled. No academic measure was taken for the RC condition. While improvements in academic productivity were demonstrated in the DRO condition, accuracy of performance on the reading task was not measured. This latter type of academic measure is needed to fully evaluate the efficacy of a treatment.

As mentioned previously, an issue of continuing controversy is how academic performance is effected differently by (a) reinforcement of attending behavior and (b) direct reinforcement of performance. The currently available evidence appears to support the direct reinforcement of academic behavior as the more powerful intervention. Response cost has been shown to be the more effective reinforcement technique; it has the additional advantage of relative simplicity of administration.

<u>Cognitive Behavior Therapy</u>. Initially referred to as "verbal self-control" (Bem, 1967) and "cognitive self-guidance" (Meichenbaum & Goodman, 1971), cognitive behavior therapy for the A.D.D. child has generated numerous research studies. Generally the approach consists of modeling or teaching strategies to use in specific circumstances, including methods of covertly verbalizing self-instructions when cue situations are encountered. Several studies in the late 1960's and 1970's (Bem, 1967; Bender, 1976; Brown, Borden, Wynne, Schleser, & Clingerman, 1986; Bornstein & Quevillon, 1976; Douglas, Parry, Marton, & Garston, 1976; Meichenbaum & Goodman, 1969, 1971; Palkes, Stewart, & Freedman, 1971; Palkes, Stewart, & Kahana, 1968) showed significant differences in pre- and post-test measures considered to assess impulsivity and attention deployment, such as the Matching Familiar

Figures Test, Trail Making, the Embedded Figures Test, the Porteus Maze Test, and certain WISC subtest scores.

According to Kendall and Braswell (1985), cognitive behavioral training in self-control involves, "(1) a problem-solving approach, (2) self-instructional training, (3) behavioral contingencies, (4) modeling, (5) affective education, and (6) role-play exercises" (p. 115). Typically, however, references to a cognitive approach do not imply the use of contingency management. The cognitive training described by Meichenbaum and Goodwin (1971), similar to Kendall's approach in other aspects, does not propose reinforcement strategies. Through the use of modeling, role play, and education, cognitive self-instructional training generally involves helping the subject recognize a problem, identify its specific characteristics, and develop a strategy for resolving the problem by contemplating alternative solutions in terms of their predicted consequences. The child is taught to reinforce himself or herself verbally with covert statements such as, "Hey, I did a good job that time!" Studying impulsive third and fourth graders, Nelson and Berkimer (1978) looked at the effects of such a cognitive training program with and without the self-reinforcing component. Based on an analysis of variance of Matching Familiar Figures Test scores, the authors concluded that self-reinforcement is a necessary aspect of cognitive training for this population.

Cognitive training studies typically have not attempted to show generalization of behavioral effects to naturally occurring environments, such as the classroom. Those that have done so report negative findings (e.g., Douglas et al., 1976, using the Conners scale; Graybill, Jamison, & Swerdlick, 1984, using the Devereux scale) with the exception of Guevremont, Tishelman, and Hull (1985) and Bornstein and Quevillon (1976). Guevremont et al. (1985) showed increases in classroom academic performance and on-task behavior. Methodological problems reduce the significance of their results, however. These problems include overlooking the accuracy of classroom performance in favor of a productivity measure, and failure to keep behavior raters blind to the experimental conditions.

Bornstein and Quevillon (1976), using a single case experimental design with preschoolers trained outside the classroom, employed two important variations to the cognitive training paradigm. First, subjects were trained in a type of self-instruction which involved imagining cue situations in the classroom. Second, the training initially used tangible reinforcers to facilitate both attention to the model and efforts at imitating it. Attention to task was observed to improve in the classroom following treatment. No academic measures were taken. Kendall and Finch (1978), using a group comparison design and teacher rating scales, reported generalization of behavioral improvements to the classroom following cognitive training with reinforcement of training responses. As Abikoff and Ramsey (1979) pointed out and as the authors (Kendall & Finch, 1979) subsequently acknowledged, pretreatment differences between the experimental and control groups on measures of classroom behavior make interpretation of these findings difficult.

An attempt to replicate the results of the Borstein and Quevillon (1976) study may provide indirect evidence of the importance of reinforcement techniques during training. Friedling and O'Leary

(1979) reported that they were unable to replicate Bornstein and Quevillon's results using third and fourth graders. While there were differences in the ages of the subjects, the most apparent procedural difference between the two studies is Friedling and O'Leary's omission of the behavioral contingency component of the training. Citing a recent unpublished study, Kendall and Braswell (1985) suggested that generalization of cognitive training is contingent on the cognitive development of the child and on a training approach which allows children to discover for themselves the self-instructional statements pertinent to the problems used in training sessions.

Early studies of cognitive behavioral approaches to A.D.D. were inconclusive. The majority of studies lacked evidence of effects generalizable beyond the laboratory. Not all laboratory tasks showed measurable success; moreover, the tasks that did show treatment effects varied from study to study. Some researchers in the area of cognitive training began to use behavioral contingencies during training in order to approximate the powerful and consistent effects shown in that literature.

Recent research in the cognitive behavioral approach has shown qualified success at demonstrating generalization of effects when training is combined with reinforcement. In an elaborately designed experiment in an experimental classroom, Barkley, Copeland, and Sivage (1980) studied six hyperactive boys ages seven to ten using a single case ABAB withdrawal design. The study looked at the effects of a treatment package containing two types of interventions: self-instructional training in a small group, and a self-monitoring/self-reinforcing program implemented during individual seat work. Academic problems were used as example material during the training. The second treatment involved the playing of a tape recorded bell sounded at irregular intervals during the individual seat work period. Subjects were asked to assess and record whether or not they were on task at the sound of the bell. Tokens, redeemable for special activities, were given for instances of agreement between subject records and observer records, with a bonus for "honesty" (high levels of agreement). Only data from the individual seat work period, where on-task behavior was reinforced, showed a significant reduction of inappropriate behavior. The lack of effects during the small group period shows that the effects of the self-monitoring/self-reinforcing treatment did not generalize across settings, even to a setting where self-control was being trained. The use of tangible rewards contingent on attending behavior during the individual seat work, i.e., a reinforcement program with rewards based on observer ratings, may have been the effective treatment component. Faced with this possibility, the clearest conclusion the authors drew from their data was not supportive of their hypothesis: "where treatment contingencies are not directly focused on managing task-oriented behavior...no improvements of such behavior will be evident."

A major shortcoming of the Barkley et al. (1980) study was the absence of measures of academic performance. Such measures have been shown to be necessary as indicators of treatment effectiveness (e.g., Ayllon, Layman, & Burke, 1972). Academic performance in the laboratory has been shown to be responsive to cognitive behavioral training effects. Douglas et al. (1976) reported improved scores on the oral comprehension and listening comprehension subtests of the

Durrell Analysis of Reading Difficulty after teaching subjects to self-instruct on visual discrimination tasks. Egeland (1974), using a similar type of training, successfully demonstrated improvements in reading comprehension as measured by the Gates-MacGinitie Reading Test. While these results show some generalization of cognitive training to academic tasks, direct assessment of academic performance in a classroom setting would be more convincing given the distractibility common in A.D.D. children. One difficulty in this regard is the disparity between the wide variety academic assessment materials used in class and the type of materials used during training, typically visual discrimination tasks.

In a series of recent articles, Daniel Hallahan and his colleagues at the University of Virginia Learning Disabilities Research Institute have reported successful use of self-monitoring to increase attention to task and, in three cases, academic performance. Self-monitoring requires the subject to assess his or her own behavior, identify target behaviors, and record their occurrence. This procedure has been shown to be effective in producing therapeutic change on a variety of target behaviors (e.g., Gottman & McFall, 1972). The group at the University of Virginia has been exploring the parameters of the effects of self-monitoring on children with attentional deficits.

Hallahan, Lloyd, Kosiewisc, Kauffman, and Graves (1979) taught a single subject to ask himself at the sound of a cue tone whether he had been paying attention and to record "yes" or "no" for that occurrence. They reported that this self-monitoring improved attention to task and academic productivity during the performance of a written task. Hallahan, Marshall, and Lloyd (1981) used an ABABCD single case withdrawal design with two fading phases to study the behavior of three learning disabled boys who had been identified as having attentional difficulties. The authors reported clear treatment effects for on-task behavior. The concurrence of a token economy for the reinforcement of "academic and behavioral accomplishments throughout the day" (p. 410), was discounted by the authors who pointed out that no more points were earned during treatment phases than were during baseline. The effects of a contingency management system concurrent with any cognitive treatment program should not be downplayed, however, considering the above review of earlier cognitive training studies. In fact, the data from the Hallahan et al. (1981) study showed that the number of tokens awarded increased threefold when the treatment was withdrawn and decreased by half when treatment was reinstated, suggesting that some kind of relationship existed between the training and the token system. Replication of the study without the presence of a token economy is needed to help resolve this question.

Two additional studies contribute tentative evidence for the positive effects of self-monitoring on attention to task and, to a lesser extent, academic performance. Hallahan et al. (1982) compared self-recording/self-assessment with self-recording/teacher-assessment in a mixed single case design (A-BC-A-B with alternating treatments during the BC phase) studying an eight-year-old with learning and attention problems. The authors concluded that both of the treatments yielded improvement on both attending behavior and academic performance. Self-assessment of on-task behavior showed better results than teacher-assessment on the behavioral observation data. While improvement of academic performance was claimed on the basis of means for each phase, visual data inspection shows considerable within-phase variability and between-phase overlap, undermining the credibility of this part of the study's conclusions. Lloyd, Hallahan, Kosiewicz, and Kneedler (1982) showed that the self-recording component of self-monitoring was not essential in obtaining increases in on-task behavior and academic productivity.

Cameron and Robinson (1980) used a single case design, a multiple baseline across three individuals, to investigate the generalizability of cognitive training to both academic performance and attending behavior in a special education classroom. They hoped to overcome the perceived shortcomings of previous studies by (a) including academic material in the self-instructional training as did Barkley et al. (1980), and (b) incorporating self-management (self-monitoring and self-reinforcement) in the treatment package. The dependent variables were performance on math tasks, self-correction during oral reading (a non-targeted behavior) and on-task behavior. Self-correction during oral reading was measured by listening to an audio tape of each subject, and recording (a) the percentage of words read accurately and (b) the percentage of errors self-corrected. It was hypothesized that these latter two measures, assumed to be sensitive to general improvements in self-correction strategies, could show generalization of treatment effects to the non-targeted behavior.

The cognitive training in the Cameron and Robinson (1980) study consisted of training self-instructional strategies (using procedures similar to those of Meichenbaum and Goodman, 1971) and training in self-monitoring and self-reinforcement of performance on math tasks. After two sessions which focused solely on self-instructional training, subjects began bringing their in-class worksheets to the training sessions to grade themselves, awarding themselves points for correct responses. Points actually redeemable for reinforcing activities were, however, established by the trainer's grading of the worksheet. This system was modified after six training sessions with the only change being that subjects began scoring their worksheets in the classroom.

The results of the Cameron and Robinson (1980) study demonstrated the positive effects of their treatments. There were significant improvements in math accuracy for all subjects. On-task behavior increased significantly for two subjects. Rates of self-correction on oral reading errors for all subjects improved. On-task behavior for the third subject was observed to increase during baseline, a phenomenon attributed in part to the introduction of the structure of the academic measure. The authors report that the generalization of the cognitive training to the classroom math tasks was promoted by using "programming stimuli common to both the training and the classroom setting" (p. 416-417), i.e., the math worksheet was used both for training purposes and as an academic measure in the classroom. While acknowledging that when these "stimuli" were brought to the training session rewards were given for accuracy, the authors minimized the importance of the reinforcement component. It is likely, however, that these rewards had a direct effect in shaping performance on the task. Defending against the possible charge that reinforcement alone could have brought about the treatment effects, the authors advanced a questionable argument based on a comparison of their study, which used 25 to 50 difficult math problems, with a study by Ayllon et al. (1975), which used 10 simple math problems. Cameron and Robinson (1980) suggested that the reason the children in the Ayllon et al. (1975) study improved math scores with reinforcement alone was because of the simplicity of the task and because of the following additional factor. They pointed out that the subjects in the Ayllon et al. (1975) study showed immediate increases with reinforcement, suggesting that low baseline performances were due to subjects being off-task and were not a result of poor math problem-solving skills as in the case of their own subjects. Visual inspection of the Cameron and Robinson (1980) math performance data does indicate a delay in effects following the introduction of the cognitive training as if the training were taking some time to "sink in" on the subjects. A more parsimonious explanation, however, would be suggested by the following fact: two of the subjects began to improve their math scores after session three when scores began to be coupled to reinforcers, while the third subject began improving her scores after session seven when reinforcement procedures were introduced in the classroom.

An interesting aspect of the Cameron and Robinson (1980) study was their attempt to fade the cognitive intervention with the introduction of a treatment phase termed "self-management." The authors describe the self-management phase of the study as a "type of follow-up" but it was really a new form of treatment, i.e., feedback coupled with an external event which may have served as a reinforcer. Subjects were given rocket ship stickers to place on a chart, indicating the number of math problems correctly answered. If all answers were correct, they were allowed to "land" the rocket sticker on a picture of the moon. The maintenance of increases in attentional behavior and academic performance during the self-management phase can be attributed as much to the success of this feedback-plus-reinforcement intervention as to the durability of the self-instructional training. It would be interesting to examine the possibility that intervening with feedback-plus-reinforcement alone could increase the target behaviors, e.g., by introducing it first in a further study. In their article the authors promise a subsequent study to determine the relative contributions of the reinforcement and cognitive training components. This is appropriate because in both the "training" and "self-management" treatments the role of a reinforcement program may have been critical.

While a number of behavioral approaches appear to improve academic performance and on-task behavior, treatments which involve contingency management techniques are more likely to obtain clearcut results. Of these, more powerful effects are seen if the reinforcers are linked directly to the behaviors measured instead of simply being used to shape performance during training.

Psychotherapy

Most authors (e.g., Eisenberg, Gilbert, Cytryn, & Molling, 1961; Stewart & Olds, 1973; Wender, 1971) agree that individual psychotherapy is not the preferred treatment modality for children seen as hyperkinetic, MBD, etc. Safer and Allen (1976) propose that psychotherapy may help with the emotional difficulties associated with the consequences of the hyperactive pattern of behavior, but they cite no studies to support their conjecture.

Results of psychotherapy attempted with A.D.D. children are typically presented in the form of uncontrolled case studies. One such example is the work of Nirk, Rubovits, and Miles (1981). While their remedial goals are stated in terms of behavior change, they stress the importance of a therapeutic relationship in providing encouragement and emotional support to the child. Their hypothesis is that in the processes of becoming aware of inefficient coping methods and of verbalizing feelings, the child's self-regulation increases and self-esteem is enhanced. They do not explain how this occurs and they acknowledge the absence of studies to document the effectiveness of their techniques.

Comparison and Additive Effects Studies

While some of the studies discussed above made comparisons of different treatments, e.g., different reinforcement schedules, different types of self-monitoring, or different types of feedback, the studies in this section compare treatments from different theoretical backgrounds. By far the most controversial comparison of this sort is that which tests the relative effectiveness of contingency management and pharmacological treatments. Studies of this type will be reviewed in this section, as well as studies which investigated either contrasting or additive effects of cognitive behavioral training and medication, and cognitive behavioral training and contingency management techniques.

Several studies in the last ten years using single case methodology (Ayllon et al., 1975; Pelham, 1977; Shafto & Sulzbacher, 1977; Williamson et al., 1981; Wulbert & Dries, 1977; Wolraich, Drummond, Salomon, O'Brien, & Sivage, 1978) have found behavior modification to be at least as effective as pharmacological agents in the treatment of A.D.D. children. One of these studies (Ayllon et al., 1975) used direct observation of hyperactive behavior and percent-correct measures of both math and reading performance. Measuring the comparative effectiveness of medication and direct positive reinforcement of academic performance, this study showed that while both medication and reinforcement were able to reduce hyperactivity, only reinforcement effected significant changes in academic performance (about 70 percentage points). Others (Barkley & Cunningham, 1978; Conners & Taylor, 1980; Horn et al., 1983; Stroufe, 1975) have found that medication alone is inadequate to improve poor academic performance and problem-solving ability. One study (Gittelman et al., 1980) reported the superiority of medication over a behavioral approach, but the only dependent measures of this study were behavior ratings and behavioral observation. Furthermore, the behavioral approach used was not direct reinforcement of behavior, but rather involved the training of parents in general behavioral techniques (to be used in a setting different from the assessment setting) without verifying the procedures actually used. The clear majority of studies have not upheld the Gittleman et al. (1980) finding, especially when academic performance is also measured (e.g., Chase & Clement, 1985).

Using a group comparison withdrawal design, Wolraich et al. (1978) compared the effects of methlphenidate with those of a token reward system designed to reinforce positive behaviors in an experimental classroom. The token system was introduced after a baseline, then withdrawn. Half the children were medicated with methylphenidate while the other half received no medication. Both medication and contingency management showed positive results in controlling inappropriate behavior as measured by direct observation. Only the contingency management intervention, however, showed improvements in academic measures, even though the medication dosage was low (.3 mg per kg body weight per day). Interestingly, teacher rating scales indicated none of the effects shown by behavioral observation at this low dosage. Williamson et al. (1981), using a single case design, reported that Dexedrine in combination with activity feedback and reinforcement for reduced activity was more effective than Dexedrine alone in reducing off-task behavior.

Rapport et al. (1982) directly compared the effects of a response cost intervention with methylphenidate treatment on both on-task behavior and academic performance. The response cost procedure was shown to be superior to medication on both measures. In an unprecedented report, the authors' concluded that methylphenidate was effective in improving academic performance, a finding that they attributed to their use of more accurate dosage levels.

In experiment two of their 1980 study, Rapport et al. (1980) studied treatment effects in three conditions: response cost alone, methylphenidate alone, and response cost plus methylphenidate. They studied a single subject, an eight-year-old hyperkinetic girl, using an A-B-BC-A-C withdrawal design. While the study is subject to criticism due to the lack of a placebo and the lack of a response cost alone condition following the combined treatments phase, the findings are interesting. The medication treatment (5 mg methylphenidate) resulted in a slightly reduced amount of off-task behavior compared to baseline, though the data were highly variable. Academic performance measures showed no improvement over baseline with medication; reading task productivity was diminished somewhat. In contrast, the response cost procedure, either alone or in conjunction with medication, produced clinically significant improvements in task-related behavior and in academic performance, with minimal data variability. As in the Shafto and Sulzbacher (1977) and Wulbert and Dries (1977) studies, medication did not enhance the effectiveness of the behavioral treatment when the two were administered in combination. More recent studies (Chase & Clement, 1985; and Pelham, Milich, & Walker, 1986), however, have shown an increased effect when the two treatments are given in combination.

The additive effects of psychostimulants and cognitive training have also been studied. Wells, Conners, Imber, and Delameter (1981) reported that they could obtain maximum behavioral control over the hyperactive boy in their study only when they combined methylphenidate and self-control training. In a group comparison study, Cohen, Sullivan, Minde, Novak, and Helwing (1981) were not able to show additive effects using a younger population. While an experiment by Horn et al. (1983) gave support to the Wells et al. (1981) study, academic measures showed no effect until performance was reinforced with tokens exchangeable for rewards. Hinshaw et al. (1984) extended these findings, showing that cognitive training was effective in increasing the self-control exhibited on multiple behavioral measures, e.g., fidgeting and physical retaliation, while methylphenidate was useful only in reducing the intensity of responses.

The additive effect of cognitive training in combination with contingency management has also been studied. Kendall and Braswell (1982) used a group comparison design to compare the effect of two treatment packages, one using response cost alone and one combining response cost with self-instructional training. Subjects who received the cognitive training improved in teacher's ratings of self-control and in self-reported self-concept. The cognitive training provided no additive effect on a measure of academic achievement. Benefits of the cognitive training seen in teacher behavior ratings at 10 weeks were not evident after one year.

Two studies have compared the effectiveness of contingency management and cognitive training. In a study unusual for its 10-month duration, Konstantareas and Homatidis (1983) compared results (from a behavior rating scale and performance on several laboratory tests) for two matched groups, one receiving token reinforcement for appropriate behavior and task completion, the other receiving cognitive training. The two groups made largely comparable gains on the study's measures, with some differences. The number of errors on a differentiating task, designed to measure impulsivity, was observed to be less for the cognitive training group, while the contingency management group showed greater improvement on taking time to correct errors. The contingency management group showed improvements on a test of sequencing and sustained attention, while the cognitive training group did not. Bugental, Whalen, and Henker (1977) took an approach not otherwise seen in this literature when they investigated interactions between type of treatment and both (a) personality attributes and (b) medication status. The individuals in the cognitive training group were more likely to show improvements on an impulsivity measure if they were not medicated or if they "perceive a personal role in determining their outcomes" (Bugental et al., 1977, p. 876), while the individuals in the contingency management group were more likely to improve on the measure if they were medicated or showed low perceived personal causality. The authors concluded that the choice of interventions used with a hyperactive child should be in part based on considerations of such variables as self-attributions and expectancies.

Summary of the Review of Literature

Studies on the effectiveness of treatments for A.D.D. vary along several dimensions. Some of the most important of these can be defined by answering the following questions: (a) are the subjects medicated, (b) (if reinforcement strategies are used) are the measured behaviors directly reinforced or are reinforcers used only to enhance performance during training, (c) are academic measures taken over and above measures of on-task behavior, (d) is an effort made to show generalization to a naturalistic setting, and (e) how durable are the effects? On-task behavior alone is not adequate to assess treatment effects. Subjects may reduce off-task behavior without becoming more productive or accurate on classroom tasks. The Rapport et al. (1980) findings, as well as others which show treatment effects of medication for on-task behavior but not for academic performance, (e.g., Ayllon et al., 1975) demonstrate the importance of this distinction.

Research on the cognitive training approach to A.D.D. has shown mixed success at improving scores on laboratory tests. Generalization of cognitive training to the classroom has only been effective when training performance has been reinforced with tangible rewards. Self-monitoring procedures used to directly shape dependent measures such as attention to task have been shown to be effective, showing improvements in academic performance as well.

Treatments using some form of contingency management procedures have the best opportunity for showing measurable effects. There are limitations associated with the contingency management approach. Specific target behaviors require fairly specific contingency procedures as there is uncertainty about generalization across behaviors (Ferritor et al., 1972). Also, techniques such as those used in the Ayllon et al. (1975) and the Shafto & Sulzbacher (1977) studies require that the teacher be mobile within the classroom to administer reinforcements. Even when taking these factors into consideration, the behavioral approach has the distinct advantage of being substantiated with an ever-increasing body of empirical research. Research such as that done by Rapport et al. (1980, 1982) is attempting to introduce reinforcement techniques which will be less obtrusive and, therefore, more attractive to the classroom teacher.

While the adherents of the psychopharmacological approach may also appeal to a data base for their claims, behavioral approaches, without harmful side effects, have been able to effect any result that medications have produced, the primary ones being reduction in disruptive behavior and increased attention to task. Medication-based treatments cannot make a similar claim. The improvements in academic performance which result from direct reinforcement of behaviors have not been shown with any consistency in the research on psychostimulants. Academic performance is typically not measured in experiments investigating medication effects. Those studies which have looked at psychostimulant effects on academic performance have reported either no effect or detrimental effects, with a single exception. Finally, direct reinforcement effects have consistently been shown to equal or surpass psychostimulant effects in studies which have made experimental comparisons of the two approaches. While contingency management techniques have been unable to show response generalization beyond immediately targeted behaviors, there is an empirical basis for concluding that the additive effects of this approach with cognitive training is successful in generalizing training effects beyond immediately reinforced behaviors.

CHAPTER III

METHODS

Subjects

Subject Selection

Four boys, 10 to 11 years of age and residents of a southern plains state, participated in the experiment with parental consent. All subjects were elementary school children, having just completed either the fifth, sixth, or seventh grade, and were selected from a classroom setting operated through the education department of a large institution of higher learning. For purposes here, the experimental subjects are named "Cal," "Don," "Sam," and "Wes." Two control subjects were assigned to each experimental subject. Table I (in Appendix E) shows the correspondence of control subjects with experimental subjects. All names in Table I are fictitious.

Subject selection was made on the basis of the criteria for Attention Deficit Disorder established by the third edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) (American Psychiatric Association, 1980). Judges for these criteria were a licensed clinical psychologist and the experimenter. Diagnostic information was obtained from the parents and from classroom teachers, using a standardized rating scale. As directed in the DSM-III, priority was given to teacher information in case of contradictions because of teachers' greater familiarity with age-appropriate norms. The use of the rating scale in subject selection is detailed in Appendix A.

All experimental and control subjects went through the same diagnostic screening process. Only four subjects were identified as being attention deficient. All four were identified for treatment. Cal (10 years old) was reported by the home school to have a mild to moderate learning disability and to be behind in reading achievement. He was reported to be easily distracted and to have difficulty organizing and concentrating on his work. Don (11 years old) was reported by the home school to have a severe learning disability. He had been seen in the home school as impatient, and as having difficulty concentrating on and completing projects. Sam (11 years old) had fallen behind grade level in reading. He was described by the home school as having problems with visual tracking speed, with visual and auditory processing, and with distractibility. Wes (11 years old) had fallen behind grade level in several subjects. His home school teachers reported that he was having difficulty following instructions and maintaining his focus on a variety of activities, and that he was becoming discouraged in school. The control subjects had academic problems similar to those of the experimental subject to which they were assigned, but they did not meet the criteria for A.D.D.

Following intelligence testing, it was determined that none of the experimental subjects had intellectual deficits which would hamper their academic performance[1]. They were included in the research only after the parents signed a release documenting their informed consent.

The techniques used in the study were also explained to the experimental subjects. The project was described as voluntary and not a necessary part of admission to the summer school program. Parents were present while the study was explained to the potential experimental subject, and were asked to discuss it with him and to learn from him whether or not he was consenting to participate. All parents indicated in the consent form that in their opinion their child understood the nature of the study and was consenting to participate.

Subject Pool

Subjects were selected from a pool of elementary school students referred to the summer school program for exceptional children by parents, school counselors, special education teachers, regular classroom teachers, and the local Guidance Center. The primary reason for referral to the program was to help exceptional students maintain their level of academic functioning over the summer break and to give the children a positive learning experience.

Procedure

Standardized Measures

In the process of interviewing families for acceptance of a child to the summer school program, parents and home school teachers completed the Self-Control Rating Scale (Kendall & Wilcox, 1979). Immediately prior to the beginning of summer school, A.D.D.-identified students were given the Operations and Word Problems subtests of the Key Math Diagnostic Arithmetic Test (Connolly, Nachtman, & Pritchett,

1971) to obtain a standardized measure of academic achievement. Those who had not been IQ tested in the preceding year were given the WISC-R as a measure of general intelligence. Without reference to actual scores, results of the WISC-R were shared with the parents at the conclusion of summer school.

A test of attention deployment, the Continuous Performance Task (CPT) (Rosvold, Mirsky, Sarason, Bransome, & Beck, 1956; Klee & Garfinkle, 1983; Lindgren & Lyons, 1984) was administered in three different formats. One format was given seven times, once in the week prior to the beginning of the summer school program and again on the following six Fridays. The other two formats were each given twice, once in the week prior to the beginning of the summer school program and again on the last Friday of summer school.

As a follow-up, parents completed the Self-Control Rating Scale in the week following summer school. Three weeks after the subjects returned to school in the fall, home school math teachers completed the Self-Control Rating Scale. The selected subtests of the Key Math were readministered in the third week of the fall school term.

The Educational Setting

The summer school program began its 1986 program in June and ran for six weeks. Teachers were graduate students enrolled in practicum-related coursework under the supervision of the director of the summer school program. The daily program schedule, which ran from 9:00 a.m. to 12:00 noon, included language experience, reading instruction, math instruction, and activities such as arts and crafts. To the extent possible, students were assigned to math instructional groups with students of similar performance levels. This was true of the other academic content areas as well. Each of the four classroom groups involved in the study consisted of three students, one experimental student and two control peers who were not attention deficient according to the screening procedures of the study. Two of these classes (those of Don and Wes) were located in rooms of their own. Two classes (Cal's and Sam's) shared a large room.

Experimental Design

A multiple baseline across individuals design (Baer, Wolf, & Risley, 1968) was used to assess the effects of the treatment on academic performance and classroom behavior. Using this design, an attempt was made to demonstrate experimental control by successively introducing subjects to the experimental conditions and showing that significant behavior changes occurred only when the treatment was introduced.

Subjects were trained in a laboratory setting using a cognitive training component and two types of positive reinforcement for academic performance. As an assessment of effects, a non-reinforced 10-minute pencil and paper measure of academic performance was taken Mondays through Thursdays in the training laboratory (the "lab quiz"). On Fridays the CPT was administered to discover if improvements in attention deployment could be observed in a non-academic task.

An attempt was made to show the generalization effects of the training on repeated measures in the classroom, assessing academic performance and on-task behavior. A 10-minute assessment of academic performance on math computational problems (the "math quiz") was given daily to all students in the four classrooms. A second math performance measure was given in the classrooms on Fridays to test for the generalization of effects beyond computational problems. These word problems were administered during a second 10-minute period. On-task behavior was measured by direct observation and recording in each classroom.

It was decided to assess academic performance on two dimensions--accuracy and productivity--as these two results of performance were seen to reflect significantly different attentional behaviors. As an assessment of the *accuracy* of performance, math problems were graded and percent-correct scores were recorded. To allow this measure to be independent of the variable speed of subjects' work, only those problems prior to and including the last one attempted were scored for accuracy. Subjects were not told to complete a set number of problems within a given time period but were given a large group of problems and allowed to work at their own pace during a 10-minute period.

This method of scoring accuracy could lead to misleading data. For example, within a 10-minute period 30 correct responses out of 31 attempts is more impressive than two correct responses out of two attempts. As an assessment of the *productivity* of performance, therefore, the number of correct responses was also recorded. This dual method of scoring enabled a distinction to be made between (a) those error patterns which resulted from either impulsive responding or the skipping of problems and (b) error patterns which resulted from lack of productive attention to the task.

All math computational problems--those used in both the laboratory and the classrooms--were randomly generated by a computer program according to distinct rules of difficulty matched to the subjects' competency levels. These rules are detailed in Appendix B. The level of difficulty for each subject was the same in the classroom as it was in the laboratory. Subjects were given exactly 10 minutes during all assessments of academic performance. This was done so that throughout the study productivity figures (number of correct responses) would be based on equivalent periods of time.

The experiment was designed to increase the difficulty level of the math problems at any time the experimental subject appeared to be reaching a ceiling in performance. This in fact was done only once, following a sharp increase in Don's performance on one of the laboratory measures. At the beginning of week four, Don moved from addition of a three-digit number plus a one-digit number to subtraction of a three-digit number minus a one-digit number.

The length of the main period of data collection was limited to the six weeks of the summer school program. Given this relatively short period of time for the repeated measures of this study, a multiple baseline design across two subject dyads was used to minimize the duration of no-treatment baseline measurement. After treatment began for two subjects (Cal and Don), the remaining two subjects (Sam and Wes) were maintained for an additional week in the baseline condition (described on p. 63).

Data stability or a deteriorating trend was reached for certain critical dependent measures before treatment was initiated. When evaluating baseline stability, the following data were inspected:

on-task behavior in the classroom, and academic performance data from both a laboratory measure (lab quiz) and a classroom measure (math quiz). Five to seven days has been shown to be an adequate time for showing baseline stability or decline for academic and on-task behaviors (Hallahan et al., 1982; Lloyd et al., 1982; Sindelar et al., 1982). This was borne out in this study with the exception of Sam's lab quiz data which was generally declining but highly variable during baseline. Once the first subjects had begun training after week one, the baseline condition (described in the following section) continued for the other two subjects through week two.

Training

In a training laboratory housed a few blocks across campus from the summer school program, attention training occurred in three parts: (a) interaction with a microcomputer math game using an Apple IIc, (b) cognitive training to teach problem solving and to enhance generalization of skills, and (c) generalization training with token reinforcement using a 10-minute pencil and paper task. These training components and the baseline condition are described later in this section, followed by a description of the schedule used for the training.

The trainers were four undergraduate students majoring in psychology and receiving course credit. They received prior training for the following role: (a) booting-up the computer math game for each session, entering the proper level of difficulty, terminating the session at 10 minutes, and recording the results of the session; (b) administering and grading the pencil and paper task and awarding tokens; (c) administering and grading the lab quiz; (d) executing the cognitive training; and (e) supervising the subjects during the exchange of tokens for rewards. Preparation for the cognitive training included role-playing where trainers alternated in playing the part of the subject. This training of the trainers by the experimenter consisted of two hours a day for one week and focused primarily on their cognitive training role.

Trainers were assigned to subjects on the first day of summer school and these assignments did not change. While it may have allowed for trainer effects, this procedure was chosen in order to provide continuity in the cognitive training. The experimenter was present for each day of the training, monitored training procedures for consistency across subjects, and provided daily feedback to each of the trainers.

Computer Math Game Training. The computer math game training involved the use of a commercially available interactional software program. Subjects engaged in one 10-minute session Monday through Thursday. They were able to take as much time as they needed for each problem, but were not able to hurry the program, which placed a short delay between the completion of one problem and the presentation of the next. The particular computer math game which was purchased was selected due to its ability (a) to direct the attention of the subject to math problems through the use of graphics and sound, (b) to allow for the screen entry of interim steps in larger multiplication problems, (c) to allow for the screen entry of answers from left to right or right to left, (d) to provide feedback on the correctness of answers and to reinforce correctness with interesting graphics and sound, (e) to provide subjects with corrected answers after an error, (f) to enable subjects to study a problem after it is answered, (g) to maintain a record of performance, (g) to control the difficulty level of the problems at the beginning of each session, (h) to alter the level of difficulty in response to the subject's performance, and (i) to provide the experimenter with control over the number of tries given per problem. Subjects were given only one try at each problem. This was done to discourage impulsive responses which might occur if the subject thought he had more than one opportunity to obtain a correct answer.

During the computer math game training component, the percent of all answers which were correct and the number of correct responses were recorded and stored on disk for each training session (see section on dependent measures). Subjects performing at 80 percent accuracy were reinforced with immediate access to other computer games. A modified changing criterion design governed the administration of the reinforcement. While the criterion for reinforcement remained at 80 percent accuracy, the difficulty level of the problems presented by the computer math game increased. This design, which was explained in simplified form to the subjects, was used to help shape improved performance on math problems. The design was also used to show experimental control of the behavioral contingency over the accuracy performance measure taken during interaction with the computer math game. A record of subject performance was kept for each session, noting whether or not the child reached the preset criterion and received the positive reinforcement.

Don used the addition version of the computer math game. The other subjects each used the multiplication version.

Computer-Assisted Cognitive Training. In addition to the computer math game, subjects were engaged in cognitive training for fifteen minutes Mondays through Thursdays to teach them problem-solving skills, to help them apply those skills to math problems, and to help them associate skills learned in the laboratory with tasks that they would face in the classroom. The cognitive training component was a version of the approach most commonly reported in the literature (e.g., Bornstein & Quevillon, 1976; Douglas et al., 1976; Meichenbaum & Goodman, 1971). Subjects were assisted in learning (a) to identify critical aspects of math problems, (b) to reflect on problems, avoiding impulsive responding and improving accuracy, and (c) to develop concentration skills and set productivity goals. Strategies used by the subjects during the computer math game training and during the various academic measures of this study were discussed with them.

There were six phases to the cognitive training. Upon mastering one phase, individual subjects advanced to the next phase at their own pace. The phases were given names to facilitate both the communication between the trainers and the experimenter and the monitoring and shaping of each subject's progress in training. These names were not used in the actual training sessions, where attention was not drawn to the phases nor to transitions between them. The beginning phases relied heavily on the use of flash cards with instructions on them. The following description of the cards presents the problem-solving steps which formed the basis of the cognitive training. The phases of training, described immediately thereafter, were designed to give the subjects practice using the steps and to encourage them to give themselves these same, sequential instructions in the classroom setting.

The first card, titled "WHICH PART?" directed the subject to first say, "Which one am I supposed to do?" and follow with, "I'm going to work on this one and try to get it right." The second card, titled "WHAT KIND?", directed the subject to look at the sign of the math problem and to say, "What kind of problem is this?" He was then directed to follow with, "This is a __________ problem," where "addition," "subtraction," "multiplication," or "division" was to be substituted for the blank. The third card, titled "THINK HARD", directed the subject to say, "OK, I'm going to work hard on this." The fourth card, titled "ANSWER", directed the subject to say, "I'm going to _______ ___ ____ ___" (e.g., multiply 16 times 4) "and put the answer there," and then to follow with "I think the answer is _________." The fifth card, titled "CHECK", directed the subject to say, "I'm going to check my answer to make sure it's right." The sixth card, titled "HOW DID I DO?", directed the subject to say, "I got it right ! I did a good job!" or "I didn't get it right, but I'll try harder next time." Each card had a simple drawing on it to help the subject immediately recall the card's contents. The cards could be cycled through several times in a single math problem as the problem was broken into its component computations. These distinct steps to problem solving were maintained in all phases of the cognitive training, though the use of the cards was phased out as the subjects began to recall their contents without looking at them.

In the first phase of the cognitive training, the trainer showed the cards to the subject one at a time, reading them aloud and explaining what should be done. This phase was termed "echo" as the subject was expected to repeat the words the trainer read. The second phase, termed "cue", involved showing the card to the subject and prompting him to read it by beginning it for him but allowing him to finish. In the third phase, termed "flash", the trainer showed the appropriate card and gave encouragement without giving instructions.

The remaining three phases of the cognitive training continued to use the cards as needed, but the trainer took only a supportive role. Termed "aloud," "whisper," and "covert," respectively, these steps progressed the subject toward acquiring skill at a covert style of self-instruction which he could then use in the classroom.

To facilitate the rehearsal of problem-solving steps, a BASIC computer program was written to present subjects with math problems at their level of competence and to allow them to enter their answers and receive feedback a digit at a time. A visual cursor (a bright rectangular marker) identified which column of the addends (or of the multiplicand) required the subject's attention at a given time. After entering the first digit of an answer, the cursor moved to a position above the next column while the program awaited entry of any amount "carried over." For example, subjects were required to place a number over the tens column noting digits carried over from calculations in the ones column.

Multiplication problems involving a two- or three-digit multiplier did not require the subject to hold partial results in memory or to note them on paper as he advanced through the solution to the problem. Instead, a separate row was provided on the computer screen for entering each of the interim products that resulted. For example, there was a row for recording the product of multiplying the multiplier's ones digit times the multiplicand, and a row for recording the product of multiplying the multiplier's tens digit times the multiplicand. At the end of that process, the problem then became an addition problem, with the number of addends equaling the number of digits in the multiplier. As before, solving this addition problem required the subject to enter above the next column any digits carried over.

The computer program informed the subject when he had made an error immediately upon the subject's entering an incorrect digit. The subject was prompted to try again. After a second error at the same part of the problem, the program gave the subject the correct answer and prompted him to enter it after figuring out why that answer was right. It then prompted him to proceed with solving the problem. The trainer was on hand to assist in reading the computer screen messages, but this did not become necessary.

Data from each cognitive training session were recorded. The phase of training was noted, as was the type and level of difficulty of the computer-presented problems. Also recorded were the number of problems worked on and the number of errors during the session. These data, presented on the computer screen at the end of a session, were also used as feedback to the subject.

Don used both addition and subtraction problems during the cognitive training. Cal used addition and multiplication problems, and Wes used multiplication and division problems. Sam used multiplication problems only.

Token Reinforcement. To improve the power of the training and to assist in generalizing training effects to the academic tasks of the classroom, a 10-minute pencil and paper task was administered with tokens awarded to reinforce the meeting of performance criteria. Performance was reinforced both for accuracy, as measured by percent correct, and for productivity, as measured by the number of correct responses. Tokens were redeemable on Fridays for access to computer games or other reinforcers negotiated in advance with the child (e.g., snacks, trinkets, toys, walks to interesting exhibits on campus, feeding ducks with the trainer). This component was considered to be useful in generalizing effects to the classroom as it did not make use of a computer, but was a pencil and paper task such as the subjects encountered in the classroom setting. For this reason this reinforced assessment of math performance is referred to here as the "pencil and paper" training.

During pencil and paper training, subjects controlled their rate of response to math problems written to meet their individual competency level. The problems were presented in a workbook with 100 problems. Subjects were told that they were not expected to answer all 100 problems but that they were to complete accurately as many as they could. At the end of the day, new sheets were added to the end of the workbook to return the total number of unanswered problems to near 100. There was no expectation of even nearing completion of the workbook at any time. The purpose of this procedure was to avoid either discouraging subjects with unfair expectations or placing an artificial ceiling on their responses.

Initial criteria for reinforcement were determined by baseline performance on the lab quiz. For each subject, the initial criterion for the reinforcement of the accuracy measure was in each case divisible by ten in order to make the concept of having a target easier for the subjects to grasp. The initial criterion was set just above the mean of the subject's best two percent-correct scores collected during the lab quiz baseline. The single exception to this was Cal whose initial criterion would have been set at 10 percent based on this rule. In order to discourage impulsive responding, his initial criterion was set at 30 percent. For each subject, the initial criterion for the reinforcement of the productivity measure was two problems above the best score which the subject had given during baseline performance on the daily lab quiz.

The criterion for the reinforcement of the accuracy measure was raised 10 percent following three of four trials at or above the criterion level. Raising the criterion stopped at 90 percent. The criterion for the reinforcement of the productivity measure was raised by one following three of four trials at or above the criterion level.

Tokens were awarded at the end of the training hour in the form of star-shaped stickers. Each subject was given the stars he had earned and was allowed to put them, on a prominently displayed poster, to the side of his name and underneath the day's date. A star for accuracy was called a "happy face" and was put under a column headed by a line drawing of a smiling face. A star for productivity was called a "strong arm" and was put under a column headed by a line drawing of an arm with a flexed bicep. The poster board itself was referred to as the "Star Chart."

During baseline, the trainers had negotiated a continuum of reinforcers with the subjects, where a specific number of tokens could be exchanged for a particular reward. Reinforcers were also identified during the course of training. Cal prized access to the computer games while Don consistently put the purchase of small toys and food at the top of his list. Wes and Sam preferred outings with their trainers and large wall posters as their top rewards.

An exception to the above procedure was used with Cal for the final week of training. In the preceding weeks, his performance had reached a plateau, and his accuracy had in fact dropped in the immediately preceding week. Cal and his trainer had decided that, should he get enough stars, his top reinforcer for the final week would be a trip to the store to buy an inexpensive item. Instead of receiving just tokens (stars) for performance in the last week, Cal also received one fifty-cent piece for each star. The fifty-cent pieces--he received five--were kept for Cal at the laboratory, and were spent by him on the last day of the study as his reward for that week. This procedure was used to make the reinforcement more tangible and immediate.

Baseline Condition. The week before the beginning of the summer school program each subject met with the experimenter for a hands-on introduction to the project and to ask questions. Following administration of the CPT, subjects were introduced to the training with a demonstration of and assistance with the computer math game. They were then given free access to the computer games to be used as reinforcers. This was done in order to allow computer game-playing to become an attractive, concrete experience which would stimulate motivated performance in the training laboratory.

Beginning with the first day of the summer school program the experimental subjects met with the trainers daily from 7:50 a.m. to 8:50 a.m. After tardiness became a problem with two of the subjects (Don and Cal) subjects would on their arrival move a card with their name on it to either a "snack" or a "no snack" column underneath a small clock, depending on whether or not they had arrived on time. Those who had arrived on time would receive a nutritious snack on their way to the classroom setting at 8:50 a.m. This eliminated the tardiness of one subject (Cal) and improved the promptness of the other (Don), whose continued instances of lateness may have been due to family circumstances.

At the end of the second week the two subjects who had begun to earn tokens on the pencil and paper task were given the reward of a trip to a duck pond. With the permission of the two subjects in training, the two subjects who were still in baseline were included in the trip in order to control for the effects of the reward activity itself.

An attempt was made during baseline to parallel the activities of the training without introducing the actual training components. During the first week of meeting with the trainers, the four experimental subjects were given a general introduction to the use of a computer. This was composed of starting a session, saving data to disk, and using the keyboard, especially controlling the movement of the cursor. In the place of the cognitive training and the computer math game, the trainer sat with the subject while the subject worked with the same software program that would later be used during the cognitive training. The trainer discussed problems with the subject, but no attempt was made to assist the subject in breaking the math problems into component parts or in any of the other self-instructional procedures that would be presented after baseline. This baseline condition was designed to control for the possible reinforcing effects of (a) attention from the trainers, and (b) access to the computer. Also during the first week, the trainers talked with the subjects individually to learn the types of rewards that would be reinforcing for them.

Training Schedule. After baseline had been established, the training took place from 7:50 a.m. to 8:50 a.m. on Mondays through Thursdays for the remaining weeks of the program. On Fridays (substituting Thursday, July 3rd for Friday, July 4th) subjects were allowed to convert tokens into reward activities.

Figure 1 shows the training schedule which was in place subsequent to baseline measurement. Rotating of the order of the laboratory experiences across training sessions is shown in Figure 1. The rationales for this were (a) to avoid creating training differences between the subjects as a result of the ordering of training components, and (b) to maximize computer hardware use.

The subject taking the reinforced assessment (the pencil and paper training) and the subject taking the non-reinforced assessment (the lab quiz) were given these academic performance tasks at the same time, seated near each other. This was done in an attempt to approximate more closely the classroom setting.

Each Monday morning the experimenter called the subjects and trainers together and spoke with the subjects about proper behavior and supported them for their efforts. Subjects were urged to talk about their goals for the week, for example, what reward they would be working to receive that Friday.

Another group meeting was held on Fridays. In that meeting, the Star Chart was reviewed, each subject was supported for his positive efforts, and any changes in criteria for the next week's token awards were discussed. While each subject was by that time aware of the rewards all the others were expecting to receive, the meeting was used to bring recognition to positive efforts, to motivate improved performance, and to model a constructive attitude toward the training tasks.

Trainers often brought small prizes such as stickers or unusually shaped pencil erasers which they then gave non-contingently to all subjects. Subjects put these stickers and larger stickers given as rewards on the looseleaf notebooks used in the pencil and paper task. At the end of the summer school program, each subject requested and was given these notebooks, which they referred to as their "Star Books," empty of their contents. Also on the last day of the program, following the end of the school session, the experimenter took the four experimental subjects to a video arcade where they were met by their trainers for a party.

Collection of Classroom Data

In the classroom, data was generated in three procedures: a daily 10-minute math quiz, a weekly word problem assessment, and daily direct observation of behavior. Teachers administered the academic assessments (word problems and/or math quiz) at the conclusion of the mathematics instructional period. While classmates were working with some differences in math proficiency, they were given identical math problems in order to facilitate a comparison between their performances. The math quiz was administered each day of summer school except for the final day, and, for Cal and Sam, the first day.

A teacher-completed classroom behavior rating scale was also completed daily and was used primarily to improve communication between the classroom teacher and the experimenter. Ratings were based on subject behavior during the day's math period.

Dependent Measures

Several dependent measures were taken to investigate the power of the experimental intervention to produce effective deployment of attention to math tasks:

-the Self-Control Rating Scale
-the Key Math subtests
-the Continuous Performance Task
-percent correct during computer math game training
-number of correct responses during computer math game training
-percent correct during pencil and paper training
-number of correct responses during pencil and paper training
-percent correct on lab quizzes
-number of correct responses on lab quizzes
-percent correct on classroom math quizzes
-number of correct responses on classroom math quizzes
-percent correct on word problems
-number of correct responses on word problems
-direct observation of behavior

Percent-correct data on academic performance was obtained by multiplying 100 times the quotient of the number of correct responses divided by the number of answers:

100 x (# correct / # answered).

This statistic, reflecting the accuracy of responding, was expected to be sensitive to changes in impulsive responding. Number of correct responses was calculated as a measure of academic productivity. This statistic was obtained by simply counting the number of correct answers for each 10-minute assessment.

The Self-Control Rating Scale

The rating scale to be used in subject selection, the 33-item Self-Control Rating Scale, was developed by Kendall and Wilcox (1979) and is included in Appendix A. This rating scale was selected for its inclusion of the great majority of the DSM-III criteria for diagnosing A.D.D., and for the clarity of its item wording. Studies on this instrument claim to distinguish between hyperactive and conduct disordered children (Robin, Fischel, & Brown 1984), to predict disruptiveness in the classroom (Kendall, Zupan, & Braswell, 1981) and in the laboratory (Kendall & Wilcox, 1979), to be sensitive to the effects of cognitive-behavioral training (Kendall & Wilcox, 1980; Kendall & Zupan, 1981; Kendall & Braswell, 1982), and to produce a 66 percent agreement between parents and teachers (Robin et al., 1984).

The pre- and post-training measures were obtained both from the subjects' parents and from the subjects' home school teachers. Post-test measures from parents were received in the week following the end of the program. Three weeks after the beginning of the 1986-1987 school year, post-test measures were obtained from home school teachers.

The Key Math Subtests

The Operations subtests and the Word Problems subtest of the Key Math Diagnostic Arithmetic Test (Connolly, Nachtman, & Pritchett, 1971) were used as a pre- and post-training assessment of achievement, with special attention given to the written calculation subtests. Sattler (1982) stated that the test "provides useful information that can guide teachers in their selection of appropriate procedures for remediation of arithmetic deficiencies" (p. 267). According to Kratochwill and Demuth (1976) the item content of the Key Math has a broad range and diversity which, together with the lack of reading and writing requirements, make it attractive for use with exceptional children.

The test was given in the spring of 1986 upon identifying the child as A.D.D. and again in the third week of the 1986 Fall semester. Scores were used to help place subjects at competency levels in mathematics and to evaluate the combined effect of the experimental training and the math instruction the subjects received while in the summer school program.

The Continuous Performance Task

Designed by Rosvold and his colleagues (Rosvold et al., 1956) to detect and to study the effects of brain damage, the Continuous Performance Task (CPT) has been described by Loney (1980, p.269) as "probably the most useful" of the available laboratory measures of attention. Sequences of stimuli such as letters are visually presented and the subject identifies whether or not a target stimulus appears. Both omission and commission errors are recorded. The designers of the instrument suggested in their initial study (Rosvold et al., 1956) that the differences they observed between normals and brain damaged individuals were due to decreased alertness in the index group. Since then, the test has been used to measure attention in hyperactive children (e.g., Sykes, Douglas, & Morgenstern, 1973). Sostek, Buchsbaum, and Rapoport (1980) have speculated from their data that numerous commission errors on the test result from a child's impulsivity while numerous omission errors are an indication of attention deficits.

Using a version of the instrument designed for use with a microcomputer, Klee and Garfinkel (1983) correlated CPT performance with commonly used measures of inattention, distractibility, and impulsivity, i.e., the Coding and Arithmetic subtests of the WISC-R, the Kagan Matching Familiar Figures Test, and the Conners Teacher Rating Scale. They found that the CPT showed significant positive correlations with the other psychometric measures. Their findings did not give support to the Sostek et al. (1980) hypothesis of specific relationships between types of errors and either impulsivity or inattention. Horn et al. (1983) have also used the CPT to measure sustained attention, showing increases pursuant to Dexedrine administration. In the report on their study, these authors argue that the test can be used as a repeated measure on a twice a week basis without concern for practice effects.

In the current study, three versions of the CPT microcomputer program were purchased from Scott Lindgren of the University of Iowa. Two versions were each administered twice, once prior to the baseline condition and once on the last day of training. The remaining version was administered weekly as a repeated measure, beginning with the same test session used for the other two versions. For the following six consecutive Fridays (substituting July 3rd for Friday, July 4th), the test was administered prior to the redemption of tokens for rewards.

All administrations of the CPT took place in the attention training laboratory. The results were designed to show whether or not gains in attention deployment are seen in non-academic tasks along with improvements observed in academic performance.

The version of the CPT which was administered seven times (the CPT-2) required the subject to watch the computer screen as a series of large letters were displayed. The subject was to depress a key when he observed an "H" to be followed by a "T". The versions of the measure which was given twice (CPT-3) displayed colored geometric shapes instead of letters. For the "Respond" version, the subject was to depress a key when he observed a blue square. This version was given to help assure that the results of the other version, given seven times, were not due to practice effects. Both of these versions of the CPT--the CPT-2 and the CPT-3 Respond--scored performance in terms of errors of omission (failing to respond to the "H-T" pattern or the blue square) and commission (depressing the key when the "H-T" pattern or the blue square had not been displayed).

A second version of the CPT-3--the CPT Inhibit--was also administered as a pre- and post-training assessment of attention deployment. It may be argued that the rules for correct responding to the CPT-2 and the CPT-3 Respond were similar enough that practice on one could effect performance on the other. The CPT-3 Inhibit was given as a measure which could be relatively free from such effects.

The CPT-3 Inhibit required the subject to depress a key whenever a non-target stimulus was presented and to inhibit the response at the sight of the target (the blue square). According to Lindgren and Lyons (1984), "the 'Inhibit' task... makes demands on the ability to rapidly initiate and inhibit motor response patterns in a way that the standard CPT does not" (p. 1).

For the CPT-2 and the CPT-3 Respond the time between stimulus presentations was set at six tenths of a second. The setting for the more difficult CPT-3 Inhibit was seven tenths of a second.

Academic Performance During Training

In the training laboratory, both accuracy (percent correct) and productivity (number of correct responses) were obtained on math tasks presented in three different formats. First, math problems were presented visually on a microcomputer monitor and responded to by use of a keyboard. Subjects who met a preset accuracy criterion for their responses during the 10-minute computer math game training received positive reinforcement. Second, a pencil and paper task presenting math problems of a similar level of difficulty was also used to provide data on both the percent correct and the number of correct responses. This task also had a 10-minute time limit. Performance on both tasks were reinforced as discussed in the section above describing the training. Because the computer math game enforced a delay between the presentation of problems, data generated by interaction with the computer, especially the productivity data, are not directly comparable to the other academic measures of this study.

A third task, the lab quiz, was given without consequent reinforcement. In this task subjects were given their own workbook with 100 math problems and asked to complete accurately as many as possible, with no tangible inducement. After exactly 10 minutes the workbooks were returned to the trainers and the percent correct and the number of correct responses were scored. In the next session, subjects were given their old workbooks to continue their work; new sheets were added to the workbook binder as old sheets were completed. As with the pencil and paper training, subjects were told that sheets would be added and that they were not expected to complete the workbook.

Academic Performance in the Classroom

Classroom Math Quizzes. All students in the four summer school classrooms were quizzed Monday through Friday of each week on math problems. The math quiz had a strict 10-minute time limit and presented computational problems at a level of difficulty comparable to the level of instruction. Students were given their own workbooks with 100 problems and told to complete accurately as many as they could. At the end of the day, new sheets were added to the end of the workbook to return the total number of unanswered problems to near 100. Students were told that there was no expectation of even nearing completion of the workbook at any time. As noted in the discussion of the laboratory measures, the purpose of this procedure was to avoid placing a ceiling on responses without overwhelming students with unreasonable expectations. Quizzes were graded and the percent correct and the number of correct responses were recorded. The quiz grade was not reported to subjects in order to minimize differences across classrooms in the naturally occurring contingencies which would accompany such feedback.

Classroom Word Problems. Friday of each week--substituting Thursday during the week of July Fourth and during the final week of summer school--an additional academic assessment was made in the classroom. The purpose of this measure was to help determine whether the attention training was merely providing subjects with practice at computation rules, improving their academic skill, or if they were learning to increase attention deployment in a way that generalized to other academic tasks. The use of math word problems for this assessment task was considered to involve the solution of problems different enough from the tasks of the training program to assess the generalization of the effects of the attention training.

The task was composed of five word problems written to require computational problems at three different levels of difficulty. The first two word problems required computations at a level of difficulty--the "independent" level--just below the level used in the academic measures which presented problems numerically. This was the level at which subjects could consistently work on their own without assistance from the teacher. The next two word problems required computations at a level of difficulty--the "instructional" level--equal in difficulty to the level used in the other academic measures. This level presented problems which might require the presence of the teacher to be worked successfully. The final word problem required computations at a level of difficulty--the "frustration" level--just above the level used in the other academic measures. This level presented problems which the child was not expected to be able to complete. The rationale for this three-level approach was to keep the task from being too difficult while at the same time avoiding an artificial ceiling on responses. Determination of the levels of difficulty was based on the achievement of the experimental subject. Controls' achievement levels were not identical to those of the experimental subjects.

The task was scored, resulting in accuracy and productivity scores which were then recorded. The results of the word problem task were not reported to the subjects.

On-task Behavior

A Classroom Behavior Rating Scale. A classroom behavior rating scale was designed for this study and is included in Appendix G. Intentionally brief to support its use during the administration of the math quiz, the rating scale was completed daily by the classroom teacher. Items provided for a repeated measure on some of the behaviors rated on the Self-Control Rating Scale by the parents and the home school teachers. Two additional items were solicited from the teacher: (a) an appraisal of the number of problems worked on in a series without supervision; and (b) an estimate of the percent of time spent on task, percent of time preoccupied, and percent of time being disruptive. No training was given to the teacher as this rating scale was only intended to be a rough indicator to aid the experimenter in shaping the training program.

Direct Observation of Behavior. During a 40-minute period of class, each experimental subject and a control classmate were observed in the classroom for on-task behavior. The 40-minute period was divided into eight five-minute segments, each comprised of 25 15-second intervals. The experimental subject and the control subject were observed separately at alternating five-minute segments, so that each was observed for a total of 20 minutes per day. They were observed five days per week (four days during the week of July Fourth and the final week) for a total of 28 observation sessions. Behavioral observations were made during a period which included both math instruction and the math quiz. The primary observers and reliability checkers were all undergraduate students majoring in psychology and receiving course credit. Four observers served as primary observers, two as reliability checkers, and one as an additional reliability checker to check for observer drift. This latter, observer-drift checker always made observations simultaneously with the primary observer and the reliability checker. Fifty percent of the observations were checked for reliability. For each subject, at least two observation sessions each week were checked for reliability, and at least one session each week was checked for observer drift.

Observers were trained using role play and observation of children in a test-taking situation. Following five-minute practice sessions, observers met to discuss differences in scores, comparing notes they had made as to the reasons for their scoring and arriving at a consensual agreement with the experimenter. They then began another five-minute practice session. Training was continued for five days until all observer combinations had reached at least a 90 percent reliability for four consecutive 5-minute observation periods.

During actual observation in the classroom the reliability checker was positioned in such a way that independence of recordings was maintained. Disintegration of observer agreement over the course of the study would have resulted in recalibration through additional training, but this was not required.

Primary observers were assigned two subjects each. These assignments continued unaltered throughout the study. The observer recorded the behavior of one subject for twenty intervals, then the other subject for twenty intervals. Using an audio tape player and headsets, distinctly different sounds (i.e., the sounded name of the subject) were heard identifying which subject to observe for any given interval. The number of the interval was then given to cue the observer when and where to record. Observers were not aware which student was the experimental subject.

Observers were cued on a 10-second observe, 5-second record, interval recording schedule. During a reliability check, the two observers were listening to the same tape player by way of a Y-plug and extension cables for the headsets. Two Y-plugs were used when the observer drift checker joined the reliability checker for observations. The tapes for the observers were made using a microcomputer system including a speech synthesizer and a clock accurate to a tenth of a second. The subjects' names were constructed from phonemes and were measured to take identical periods of time on the tapes. Likewise, the numbers called out on the tape identifying which interval to mark were generated to take the same amount of time. From the beginning of the subject's name to the beginning of the cue to record was exactly 10 seconds, then exactly five seconds transpired until the sound of the subject's name.

In order to alternate the order of observations, two tapes were made for each primary observer. One side of a tape cassette began the observation session by directing the observer to first observe the experimental subject. Then after five minutes the observer was to observe the control subject. The next day the observer turned the tape cassette over to listen to the tape with the opposite ordering. This was done so that neither the experimental subject nor the control was always observed at the beginning of class which may have been a time of reduced on-task behavior.

Observers recorded behavioral observations using the following definitions:

1. on-task behavior (all required)
   - (a) staying at the seat, head directed toward work
   - (b) keeping the pencil in hand
   - (c) not singing or playing, e.g, tapping the pencil
   - (d) not talking to or distracting others
   - (e) not fidgeting (repeated limb movement or rocking)
2. off-task behavior (only one required)
   - (a) staring
   - (b) fidgeting
   - (c) talking to self
   - (d) out of seat
   - (e) talking out of turn
   - (f) distracting others

On-task behavior was recorded in a whole-interval recording procedure, i.e., the subject had to be on task for the entire interval for the interval to be scored as an occurrence of on-task behavior. Any off-task behavior during the interval resulted in the interval being scored as a non-occurrence of on-task behavior.

Reliability Determination

Reliability for the observational data was determined according to the following procedure. Reliability scores for the occurrence and non-occurrence of on-task behavior were calculated by means of the formula: agreements over agreements plus disagreements times 100:

$$[\#\ \text{agreements} / (\#\ \text{agreements} + \text{disagreements})] \times 100$$

Percent reliability was calculated for each subject for each day and results were averaged to arrive at weekly figures.

Tables II, and III, and IV (in Appendix E) show the reliability of observational data, respectively, for the primary observer and the reliability checker #1, for the primary observer and the reliability checker #2, and for the two reliability checkers. Reliability percentages, indicated for each week and for each subject, range between a low of 80 percent and a high of 100 percent. A mean for each subject was obtained across the entire study based on the first reliability score of the primary observer and the reliability checker #1. These means are shown for each subject in Table II.

All pencil and paper math problems were graded by two scorers on hand calculators. When differences in scores were encountered, the experimenter continued to calculate the correct solution to the problem until two consecutive answers agreed.

The computer math games were each tested for reliability in four trials of 100 problems each. No errors in the reliability of scoring were found in the software programs.

Data Analysis

Academic performance on the computer math game was plotted in graph format to allow for visual inspection. The changing criterion design was used to show the effectiveness of the contingency management in differentially reinforcing successful attending to math problems during the computer math game training.

Other data obtained in the laboratory were also plotted in graph format. Through visual inspection it was determined whether or not the token reinforcement affected the reinforced task, and whether or not the effects of the treatment package generalized to non-reinforced laboratory measures, both academic and non-academic in nature. The classroom data (behavioral observation, math quiz, and word problems) were graphed to demonstrate the generalization of the effects of the treatment program to a non-laboratory setting.

The multiple baseline design allowed for an evaluation of the effectiveness of the training. The laboratory data and the classroom data were visually inspected to examine changes in academic performance and task-related behavior concurrent with the introduction of training.

The CPT and the word problems helped to show whether improvements on math scores were due to increased attention deployment or to practice effects. The Self-Control Rating Scale and the Key Math subtests indicated the extent that treatment effects were maintained over the summer and generalized to a different setting.

FOOTNOTES

[1]When originally asked, parents of each of the experimental subjects confirmed that their son had not been IQ tested within the last 12 months. The WISC-R was administered in June, 1986, and all four subjects tested above 80. Don had the lowest Full Scale score, that of 82. After the study was underway, Don's mother recalled that he had been given the WISC-R at school only months earlier. At that administration he was given a Full Scale score of 69. In discussions with the director of the summer school program and with the licensed psychologist who had clinical oversight over the project, it was decided to continue with Don as an experimental subject.

One factor in this decision was that Don was already invested in the training program and his potential for benefitting from it was seen as high. Also, the summer school program director had previous knowledge of Don's functioning and believed that his IQ score may not reflect his intelligence due to a severe learning disability. She had tested him prior to his school experience. She concluded that his subsequent drop in IQ was a result of his not having benefitted from school due to his severe learning disability.

It was noted that the differences between the February and June WISC-R administrations included differences in verbal subtests --totaling nine scaled score points--which were not likely to be influenced by practice. This suggested that situational factors may have had a part in the differences in his performance.

In addition, Don's Performance IQ was lowered significantly in the earlier measurement by a CODING scaled score of 02. This subtest, while administered in June and yielding the same scaled score, was determined <u>in advance</u> to be excluded in the June reckoning of Performance and Full Scale IQs in favor of the MAZES subtest. (Don's MAZES scaled score was 09.) This decision held true for the scoring of the WISC-R results for all the experimental subjects. The reasons for this were based both on the nature of the CODING task and on the characteristics of learning disabilities and Attention Deficit Disorder. Kaufman (1979) suggests that MAZES is "the far better choice" for the distractible child compared to CODING which "is more of a clerical than intellectual task" (p. 118). Others (Ackerman, Dykman, & Peters, 1976; Rugel, 1974) have pointed to the sensitivity of the CODING subtest to learning disability, making it a valuable part of a battery when testing the learning disabled child, but holding it suspect as a score to be included in the calculation of IQ.

CHAPTER IV

RESULTS AND DISCUSSION

Laboratory Training Measures

Figures 3 through 6 (in Appendix D) show the measurements taken during the training sessions in the laboratory. Each figure is composed of two parts (e.g., 3.1 and 3.2): the first part graphs the progress of Cal and Wes, the second part graphs the progress of Don and Sam. These pairings were designed to show differences between subjects who began training after differing baseline lengths (One week: Cal and Don; two weeks: Wes and Sam). This comparison is primarily useful for those figures which include baseline data. The same graphic layout was used for all the laboratory measures, however, in order to facilitate review of the data. To provide continuity of labeling with latter figures, which will include data from control subjects, subjects are labeled "exp" in Figures 3 through 6 indicating that they are experimental subjects.

Computer Math Game Training

The four experimental subjects showed varying degrees of progress in accuracy and productivity during use of the computer math game. The results of these changes over time are shown in Figures 3 and 4 (in Appendix D). The solid vertical line shows the beginning of training. For two subjects, Cal and Sam, the game and subsequent rewards for accuracy appeared to retain their reinforcing quality throughout the study, as indicated by the maintenance of accuracy scores near the 80 percent criterion mark. To a lesser degree, Don showed responsiveness to the reinforcement. While he failed to meet criterion four times in the last two weeks, he was successful three times. His drop in performance in weeks five and six is likely to have been affected significantly by the increase in difficulty of the math game problems. It was an artifact of the computer program that consistently high performance would cause the subject to reach difficulty levels where his performance would fall.

While initially showing response to the reinforcement criterion, Wes dropped in performance after a week. The reasons for this may have included the increase in the difficulty level programmed into the game, lack of interest in the games used for reward, boredom with the math game itself, or a general tiring of dealing with computational problems after weeks of intensive work. Given the pattern of responding shown in Figure 4.1, the most predominant cause for Wes' performance drops was likely to have been the computer game's automatic and rapid increase in difficulty after improved performance.

The productivity measure was not reinforced during the computer math game training and showed a different pattern. The two subjects who maintained the accuracy criterion failed to show consistent progress on the productivity measure. The large initial increase in both accuracy and productivity for Cal was due to a lowering of the difficulty level of the problems after the first day's trial. This adjustment was made because it had been originally been set too high. The remaining two subjects showed a falling off of productivity in the final two weeks of the study, roughly paralleling their diminishing performance in accuracy. The decrease in productivity was not surprising, as the more difficult problems they faced late in the training involved more calculations per problem.

Computer-Assisted Cognitive Training

The course of the computer-assisted cognitive training was recorded in four ways: 1) the phase of training, 2) the type and level of difficulty of the problems, 3) the number of problems worked on, and 4) the number of errors. These data are presented in Table V (in Appendix D) to show acquisition of problem-solving skills during the course of the cognitive training. The data in Table V show that for Cal and Don the training did not progress through phases to the stage of covert self-instruction until late in the six weeks, giving them minimal practice with it. Wes and Sam, who began training in week three, were not advanced beyond the stage of calling the instructions out loud. This incompleteness of the training could be predicted to have limited the subject's use of self-instruction in the classroom.

Token Reinforcement

At the beginning of the baseline condition, the four experimental subjects were each given a single workbook with 100 math problems randomly generated at their respective levels of difficulty. The difficulty level remained constant for all subjects' problems except for Don's problems, which increased in difficulty at the beginning of week four. The workbooks were kept in the laboratory and used for the "lab quiz" data. At the initiation of training, a second workbook was given to each subject for the pencil and paper task, which was reinforced by a token system of rewards.

Data from the pencil and paper task are shown in Figures 5 and 6 (in Appendix D). Because of the similarity between the ways this measure and the lab quiz were administered--the only difference was the reinforcement--the baseline data from the lab quiz are also shown in Figures 5 and 6 to demonstrate the effects of the introduction of reinforcement. While pencil and paper data are indicated by a solid line between data points marked by an "x," the lab quiz data is marked by use of an "o" and a broken line. In Figures 5 and 6, as in all the data graphs, the solid vertical line shows the beginning of training which was, in this case, token reinforcement for accuracy and productivity on the problems presented.

In both percent correct and the number of correct responses, experimental control of the reinforcement paradigm was demonstrated over the test-taking behavior of all experimental subjects. Incremental raising of the criteria for reinforcement was responded to by all subjects with improvements in their performance.

Generalization to Laboratory Assessments

Academic Performance in the Laboratory

The training measures discussed above were useful in tracking the progress of the subject through training and in determining the degree to which the subjects were engaged in the training. The training itself, however, was designed to enable the subject to apply newly acquired skills to tasks beyond the training situation and its related contingencies. Visual inspection of the data in Figures 7 and 8 (in

Appendix D) shows improvements for all experimental subjects in non-reinforced academic assessments of accuracy and productivity taken during the repeated lab quiz. While, especially in Don's case, these data show more variability than the data from the reinforced measure, the finding is significant in that it demonstrates that the effects of the training package generalized to a non-reinforced measure. As with the reinforced task, the difficulty level remained constant for all subjects' problems except for Don's problems, which increased in difficulty at the beginning of week four.

Figure 7.1 (in Appendix D) shows the increases in Wes' performance after the introduction of training, and though he loses consistency in the concluding days of the study, he clearly demonstrates improvement in solving these problems without external management of contingencies. This effect is most clearly shown in the record of Sam's accuracy data, which is displayed in Figure 7.2. (in Appendix D). Careful note should be made of the fact that the spike from zero percent correct to 100 percent correct came on a day that he attempted only one problem. His accuracy performance curve can be observed to remain high as his productivity improved, which is the same pattern he showed on the reinforced measure in the pencil and paper training.

In fact, comparison of Sam's graphs for performance on the reinforced pencil and paper task (in Figures 5.2 and 6.2) with graphs of his performance on the nonreinforced lab quiz (in Figures 7.2 and 8.2) shows remarkable similarities. While the clustering of data points around the reinforcement criterion shows experimental control over the reinforced performance, his performance on the non-reinforced measure improves in a similar pattern. This lends additional credibility to the view that his response to the reinforcement regime was generalized to the non-reinforced task. Don's performance can also be seen in Figure 7.2 to have improved significantly, though with less consistency than Sam's.

During the course of training, Sam had a large percentage increase over baseline in his productivity score on the lab quiz. While in real numbers this was not much--a high of four correct answers compared to high of two in baseline--the increase was fairly consistently maintained. Sam expressed a large measure of satisfaction at these scores, as he was keenly aware that he worked more slowly than most his age.

Continuous Performance Task

The CPT is a vigilance task which requires the attentional skills of concentration and self-control, and one in which facility with numbers could only play a minimal role if it played one at all. This measure was included in the study to help determine whether or not improvements in academic performance were the result of strictly scholastic skill-building or if the training could be credited with building attentional skills which could be deployed when engaged in other sorts of tasks.

Figures 9 and 10 (in Appendix D) show the results of the repeated measures using the CPT. Improvements in both errors of commission and errors of omission on the CPT-2 were seen for all experimental subjects. Generally, errors of commission improved more than errors of omission. This finding is difficult to interpret in the light of

Klee and Garfinkel (1983) study which did not support the Sostek et al. (1980) hypothesis of direct relationships between commission errors and impulsivity on the one hand, and omission errors and inattention on the other.

An exception to the overall pattern of CPT performance among the subjects was the radical increase in commission errors for Cal on the last day of the study (see Figure 9.1). These latter data are quite inconsistent with the trend of Cal's earlier performance. These data may indicate a negative swing in Cal's self-control and/or motivation on the last day of the study, possibly influenced by unintended and unidentified changes in the experimental environment. Cal's omission errors did not show as great an increase on the last day of measurement as did his commission errors, suggesting that he was attending but responding without his previous concern for accuracy.

Overall, the subjects' improvements in CPT-2 performance appear to have been related to training effects, as decreases in errors generally were more clearcut starting with the onset of training. This observation is not applicable to Cal's number of commission errors, as these data showed clear improvement during baseline.

With the exception of Cal, subjects showed noticeable improvements in performance on both of the CPT-3 tasks. This is particularly evident with Wes' reduction in CPT-3 Inhibit errors from 24 to 5. While not as dramatically evident, Don and Sam also showed improvement. These pre-treatment to post-treatment improvements on the CPT-3, which was administered only twice, suggest that the improvements on the CPT-2 were not due to practice effects. It should be pointed out, however, that all CPT tasks were computer-presented and required keyboard input. In the interval between CPT-3 administrations, subjects had considerable experience with both the presentation and input factors, possibly favoring an increased performance for the second administration.

Overall, the CPT data show a generalization of the effects of attention training to a non-academic, laboratory task. The strongest performance was that of Wes, who reduced CPT-2 errors of both commission and omission to zero by the last week of the study. This result is clearly not influenced by improved knowledge of the rules of calculation.

Generalization to Classroom Assessments

In the classroom, data were collected for both on-task behavior and academic performance. Daily in each classroom, the behavior of the experimental subject and of one control subject was directly observed and recorded. Daily academic measures were also given to these subjects, as well as to the third classmate in the class. Table I (in Appendix E) shows the make-up of each classroom by the names given to the subjects.

On-task Behavior

Figures 11.1 through 11.4 (in Appendix E) show the data indicating the percent of intervals each subject was on task. In each classroom, data were collected for the experimental subject (labeled "exp") and one control subject (labeled "cntl").

An increase of on-task behavior in the classroom was looked for in the observational data. This effect is not clearly demonstrated by visual inspection of the data presented in Figures 11.1 through 11.4 (in Appendix E). In one classroom (Figure 11.3) both the experimental subject and the control showed a decrease in on-task behavior. In another classroom (Figure 11.1) the experimental subject showed a decrease in on-task behavior not shown by the control subject. This latter case, from Cal's classroom, suggests that either pre-study differences, the training itself, classroom contingencies, or a combination of these factors contributed to the decline in Cal's attending behavior.

Don's and Wes' on-task behavior showed some improvements, with similarities and differences in their patterns. Both showed a decrease in on-task behavior over the weeks, followed by an increase. Don's on-task behavior, which had previously been highly variable, improved in week four, became more stable, and gradually increased. In contrast, Wes' behavior pattern became less consistent but, with the exception of "Fun Day" announced by his teacher on Friday of the fourth week, it, too, showed a generally improving trend.

Table VI (in Appendix E) presents in table format the daily percent on-task data for each subject, also providing weekly means and standard deviations. Table VII (in Appendix E) presents only weekly summaries, showing again the weekly means and standard deviations, and also the sum of squares and <u>n</u> for each mean.

Reasons for the failure of the training to produce increases in on task behavior will be discussed in Chapter V. These include a critique of the observational procedure itself.

Academic Performance in the Classroom

Daily Computational Assessment. Data showing performance on accuracy measures (Figures 12.1, 12.2, 12.3, and 12.4) and on productivity measures (Figures 13.1, 13.2, 13.3, and 13.4) are included in Appendix E. In each classroom, data was taken from the performance of the experimental subject and two controls. These controls included the control subject used for the on-task data and one additional control in each classroom. These additional control subjects were fictitiously named "Ted," "Ray," "Ean," and "May," and are labeled "cntl."

While some increases were obtained in the performance of the experimental subjects on the in-class academic measures, these did not, with two exceptions, differ significantly from the performance of the controls in each classroom. This finding (with the two exceptions noted) and the differences between the subjects' pretreatment baselines makes it difficult to attribute observed academic progress to either the training or the in-class instruction.

Figures 12.2, 12.4 and 13.2 (in Appendix E) demonstrate the exceptions noted above. In Figure 12.4 visual inspection shows Wes, in the accuracy of his responses, to have made a significant improvement in his performance over baseline. While both of his classmates maintained a level of performance above 65 percent, the degree of their progress did not parallel Wes'. A ceiling on performance may have contributed to this fact, which was unavoidable due to their having begun at a level of performance much higher than had Wes. Wes did, however, conclude the summer school session scoring as high or higher than his classmates, a fact that is particularly significant considering the differences in their performance at the beginning of measurement.

Figure 12.2 (in Appendix E) shows Don's accuracy on the classroom math quiz. He, too, has classmates who outperformed him initially. Although the performance seen for Joy (a control subject) may have been artificially limited by a ceiling effect, her performance record in Figure 12.2 suggests otherwise, showing occasions of her dropping to accuracy scores of 70 percent and less. (The performance of Ray--another control subject--shown in Figure 12.2 was likely to have been disrupted by the emotional problems and conduct disturbances which brought him to the summer school program.) Don's performance was highly variable but was maintained at an improved level.

Sam's accuracy performance on the classroom math quiz (Figure 12.3 in Appendix E) shows the same uneven performance pattern across days. What distinguishes Don's performance, in addition to a sharp improvement at the onset of training, is that even his worse days remained improved over baseline.

Figure 13.2 (in Appendix E) shows noticeable increases in Don's productivity in the math quiz. The increases began in the second week after he entered training and are generally maintained at an improved level. Don ended his performance record with his high score of 23 correct answers, well above his baseline pattern where his highest score was four. Wes (see Figure 13.4 in Appendix E) made a small improvement in in-class productivity over baseline, but so did one of his control classmates. Sam (see Figure 13.3 in Appendix E), who showed slight improvement in productivity late in the study, did not improve as much as his classmates. Cal (see Figure 13.1 in Appendix

E) did not show improvement, though his classmates did.

Weekly Word Problem Assessment. Figures 14 and 15 (in Appendix E) show the results of the weekly word problem assessment in the classroom. An interesting point in the data is shown on Figure 14.4 when Wes, on his own, realized in week four that the word problems task contained only multiplication problems. This insight was likely to have been influenced by instruction in the classroom on how to understand word problems in general. While the experimental subjects showed improvements on the word problems task (see Figures 14.1, 14.2, 14.3, 14.4, 15.1, 15.2, 15.3, and 15.4 in Appendix E) so did their classmates. Cal was again the exception, performing beneath the performance level of his classmates and not showing improvements when they did.

Follow-up Assessments

Self-Control Rating Scale

Tables VIII and IX (in Appendix F) show the results of the pre- and post-training behavior ratings by teachers and parents. Since the ratings at school were by different raters, it is difficult to interpret the data in Table VIII. Behaviors were generally rated more positively following training, but the teachers in the fall knew the subjects for only three weeks and the subject's behavior could have deteriorated after a few weeks' "honeymoon" period at the beginning of the term.

All parents' ratings were done by the same parent who initially rated the child. Important improvements in ratings can be noted in

Table IX for all experimental subjects. This may be due to less impulsive and less inattentive behavior on the subjects' parts. One possibility is that the parents were expressing enthusiasm for the child having been involved in the study and a belief that their child had made incremental improvements in attending behaviors over the course of the training.

Key Math Subtests

Table X (in Appendix F) shows the significant improvements in math achievement over the very short time between administrations. In interpreting these data, for which there is no control data comparison, their attention training and the summer school program must be viewed as a unit. It is evident that the six-week combination of small class instruction and laboratory training was effective in improving math achievement over the summer period which would otherwise have likely seen drops in performance.

It should be noted that the Key Math is not a timed test and that its subtests cover a wide range of abilities, with a minimal number of items for each ability. For these reasons, it is not possible to compare directly the results of the Key Math with the academic assessments taken during summer school which were timed and, in the case of the computational tasks, focused on a single level of difficulty.

FOOTNOTES

[1]The computer math game was not designed to be used with a 10-minute time limit. In fact, it was designed to keep the child's attention for the longer periods of time it takes to work on higher level problems. In the addition and subtraction version Don worked with, feedback for correct answers came in the form of scenes which require several correct answers to complete, for example, a bear character incrementing the number of balloons he holds until he can float all the way over a wall. This worked to the disadvantage of the study in Don's case. As the more difficult problems began to take longer, Don began completing fewer scenes, and spoke about his disappointment over the situation. He began working more quickly to try to beat the clock, and lost points in accuracy.

The main role of the computer math game in the research was not as a measure, but as a training device. As such, it appears to have been successful in motivating performance. At the same time, in the context of its use in this study, the experience of using the computer math game appeared to be encouraging impulsive responding. An intervention was made at this point (week five) with Don, and not with the other subjects. His trainer, who normally sat quietly by as Don worked with the computer math game, was told to guide Don in the use of the cognitive training problem-solving steps during his interaction with the program. This increased the time it took for him to respond, and would have exacerbated the problem without a second modification. Unlike the other subjects, beginning with Thursday of the fifth week, Don was allowed to use the computer math game as his reinforcer for meeting criterion, and continued to play after the 10-minute time limit. (He did, in fact, consistently make that choice.) The other subjects worked with a different program in which moving to a new scene required fewer correct responses.

The change in Don's training with the computer math game was part of a general understanding that children with special education needs require an individualized approach. Part of this approach is a close relationship between the teacher (or trainer) and the student and a flexibility of intervention based on the teacher's observations.

It is not clear whether the change in the management of contingencies for Don during the computer math game encouraged his productivity by making completion of scenes more feasible, or discouraged him from being productive since he was given more time to work with the program. This unknown factor made comparison of his computer math game data to that of other subjects more difficult, but this concern was seen as secondary to Don's having a rewarding experience with the computer-generated math tasks.

It should also be noted that the jumps in levels of the computer math game were not equal for Don. For example, the move from three- to four-place addition was much easier for him than was the next jump to three-place subtraction.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

In addition to a summer educational program, attention training was given to four participants, 10 to 11 years of age, using a multiple baseline design with repeated measures in the training laboratory and in a classroom. Two subjects entered training after one week; the other two followed a week later. The training was a treatment package consisting of three components: a computer math game, computer-assisted cognitive training, and token reinforcement of a pencil and paper task.

The effects of training were assessed via three comparisons of behavioral and academic performance data: (a) contrasting each experimental subject's behavior after the introduction of training to his own baseline rates, (b) contrasting the data from experimental subjects who began training after one week to experimental subjects who began after two weeks, and (c) contrasting each experimental subject's data to that of classmates who did not receive the training.

Improvements in accuracy and productivity on math problems were shown to generalize from the training to non-reinforced laboratory measures of attention deployment and academic performance for all experimental subjects. The data additionally showed some generalization of the effect to academic performance in the classroom setting, but not to on-task behavior.

A comparison was made between changes in the in-class academic performance of the experimental subjects and changes in the same data for classmates serving as controls. This was done to try to ascertain the additive effect of the training beyond that of the classroom instruction. For two of the experimental subjects, the significance of the contribution of training in improving classroom academic performance was called into question by the improvements which were also observed for the no-treatment controls. Two experimental subjects made improvements not seen in the no-treatment controls.

In a follow-up assessment, academic achievement in math and ratings of behavior were shown to have improved in comparison to pre-training data. This suggested that positive changes resulting from the combined effects of the training and the summer school program had some durability and had generalized to other situations.

Researcher's Observations

While comparisons to classmates were important in order to provide a greater sensitivity to the differential contributions of the attention training and the summer school program, it is important to recognize that the pairings of experimental subjects with no-treatment controls was not matched for the most important criterion, that is, identification of attention deficiency. All control subjects had gone through the same diagnostic screening process as the experimental subjects. The procedure had rejected the controls for the diagnosis of A.D.D. This distinction is important for the measures of this study which are designed to be sensitive to the deficiencies of A.D.D.

Comparing the A.D.D. subjects to their own baselines on such measures was, therefore, not equivalent to comparing the non-A.D.D subjects to their respective baselines. This is because the A.D.D. child can be expected to require the greater intervention in order to effect change.

According to Wilkinson (personal communication, July 10, 1987), director of the summer school program, the experimental subjects would not have made the improvements in academic performance, nor in some cases shown the degree of on-task behavior they did, without the daily experience of the attention training. It is generally true of all of the students referred to the summer school that, previous to the program, they had not had anyone persevere in explaining problems to them until they understood. In a case by case evaluation of overall school functioning, Dr. Wilkinson pointed out that the control subjects did not require the extra intervention that the experimental subjects needed in order for the two to show roughly equivalent data. This disparity is borne out to a large extent by the differences seen in the baseline performances of the experimental subjects in contrast to those of their controls.

It is commonly known among educators that different interventions work with different students. What was it about Wes and Don and their training and/or classroom setting that helped them to generalize some skills from the laboratory to the classroom? What was it about Sam and Cal that made it more difficult for them?

Differences between the classroom and laboratory experiences are part of the answer. The time of day for each could have been one factor. Also, the lab was a one-to-one setting while each classroom teacher had three children to teach. Other differences include the number of distractions present in the room, and the predominant focus on performance in the laboratory in contrast to the classroom's predominant focus on learning. These differences between classroom and laboratory settings are normal and appropriate, but they are great enough that the laboratory is a useful setting for attention training only for some children.

One distinction about Wes' and Don's situations was that they were in the rooms where there was only one class. Inspection of the percent on-task data shows that both the experimental and the control subjects in those classrooms attended better than the experimental and control subjects in the larger, shared classroom. The degree to which this factor is significant cannot be determined within the present study.

A major contributor to the level of distractions in the classrooms was the presence of the observers. The classroom that had two classes in it would have been particularly affected by this; on some days there would be as many as five observers present. Observation through a one-way mirror would greatly diminish this disruption of the educational process and at the same time leave the data less contaminated.

The observers were trained in a setting different from the one in which data was collected. They were trained in a one-to-one setting where the subject was continually presented with a task to perform. While data was collected, however, subjects at times had no task to attend to. Rather than enter into the subjective determination of when the subject actually had been given a task, observers were instructed to ignore that factor and record that the subject was off task. This artifact of the observational system and the strict definition given to such behavioral states as "not fidgeting" could have contributed to the low percent on-task data which were obtained in this study for all subjects.

That part of the observation period which was during the assessment of academic performance (math quiz) provided the possibility of recording on-task behavior with a sustained presentation of a task. These intervals were not separately identified. If they had been, more could have been said about the effect of the training on on-task behavior and about the relationship between academic performance and on-task behavior.

The laboratory training turned out to have a greater social reinforcement component than was anticipated. A point in the data in Figure 7.1 (in Appendix D) illustrates this issue. While Wes showed a marked increase in accuracy in the lab quiz with the onset of his training at week three, so does Cal, whose training began a week earlier. Cal had shown improvement with the onset of his training at week two, but the improvement was not as dramatic as the increase observed in week three. On the one hand, it is likely that it was taking Cal longer to respond to the training. It is also the case, however, that something important happened in the lab during that week, influencing the behavior of both boys. The changes centered on the fact that the more mature Wes and Sam joined the training program that week. This was observed to increase Cal's and Don's enthusiasm for the program. At the same time the boys began to interact more as a group, swapping stories, trading possessions, and pulling pranks on each other. Group games played prior to 7:50 a.m. also emerged, games that included the trainers. The positive interactions between subjects and the role of the group in supporting goal-setting and improved performance was not planned to have this degree of importance, but these factors were encouraged once they were recognized. Because the relative contributions of the components of the treatment package were not analyzed, it is possible that social reinforcement may have been as effective in changing the target behaviors as any other component of the training.

Information about each of the experimental subjects aided in an understanding of their performance. A short section on each subject follows, reporting this information.

Wes

Wes was referred to the summer school program after having fallen behind grade level in several subjects and after having shown difficulty following instructions. He was found to have excellent social skills generally, but had difficulty sticking with an activity or a topic of discussion, and at times used baby talk to avoid dealing with a difficult math problem. His trainer found that he rushed himself during calculations and that he was easily discouraged.

In the cognitive training, Wes' trainer worked with him in both recognizing when he did well and praising himself for it, something Wes initially had difficulty doing. More than any other experimental subject, Wes seemed to enjoy the cognitive training, sometimes giving little speeches in group meetings about the importance of taking time to think, etc. He was also frequently enthusiastic about working for stars and specific rewards, such as a poster of a car he liked. These periods of enthusiasm, however, did not always include the actual time of the test-taking. It appeared to the trainers and to the experimenter that Wes would, at times, become less confident right before the pencil and paper administration. We considered that this may have been a type of emotional preparation for encountering problems too difficult for him. This pattern was observed to fade as Wes strung successful weeks together. He began to brag appropriately on his performance by pointing to his stars that he was accumulating on the Star Chart. When he earned a star on a particular day, he began a pattern of making his rounds, guaranteeing that the experimenter and all trainers knew of his success. This activity was met with encouragement from all sides.

In contrast to his these improvements on the Star Chart, Wes appeared to lose interest in the computer math game. This may have been the result of the game's rapid progression into more difficult questions after a series of correctly answered problems. This could be viewed as a source of discouragement and a negative reinforcement for accurate responding. It is possible that Wes would have benefitted from a more individualized program that required a longer string of successes before advancing the level of difficulty.

On the classroom behavior rating scale, Wes' teacher recorded improvements in three important areas. Wes' daily ratings showed a decrease in jumping from one focus to another and increases in finishing work and seeking help when frustrated. Each of these improvements were considered to have important impact on his school experience. In the rough comparison of Wes' spring and fall (pre- and post-) ratings in the Self-Control Rating Scale--completed by different teachers--these same improvements were observed.

When asked at the end of training what he liked about it, Wes showed that he had been listening during his cognitive training: "It's good, cause now I know I can tell myself to do good and, like, be proud of myself if I do a good job, even though I didn't get anything, besides that I did good." This report suggests that Wes was beginning to understand substitution of intrinsic motivation for the extrinsic token economy.

Sam

Sam was referred to the summer school program after haven fallen behind grade level in reading. He was known to have mild visual and auditory processing problems. He wore bifocals and was diagnosed as having problems with visual tracking speed. Sam stood out in his softspoken manner, his humor, and his ease at forming relationships.

Sam's summer school teacher pointed out that while he usually worked quite slowly, he was able to win the "multiplication races" they had one day. She also noticed that he was more productive on her math worksheets than he was on the math quiz of this study. She attributed this to the fact that her sheets had fewer problems per page, making them seem more manageable and less intimidating than the sheets of the math quiz. If this is true, and it is a reasonable conclusion, Sam's cognitive training fell short in helping him, when faced in class with a sheet of 20 problems, to identify the task at hand and focus on only one problem at a time. His difficulties tracking visually might have made a less cluttered page even more important for Sam. Sheets with fewer problems might have helped increase his rate of success.

Behaviorally, Sam gave the appearance of being motivated and putting forth effort. The daily ratings by the classroom teacher showed him by the end of the study concentrating better and staying with tasks until he completed them. As mentioned in Chapter IV, he was obviously happy when he earned stars in the lab, especially the "strong arm" star for the number correct, and he participated actively in the goal-setting aspects of the reinforced pencil and paper training.

Sam's training differed in at least one way from the others. He would meet early with his trainer for warm-up exercises. They were frequently joined, however, by Wes and Cal.

When asked at the end of training what he liked about it, Sam said, "getting the stars and getting to do stuff and get stickers and stuff."

Sam returned to the summer school program in 1987. At the time of the pre-admission interview, his mother spoke highly of the attention training the year before. She attributed a part of Sam's improved academic performance in the home school over the preceding year to the training. Sam was congratulated for his performance and asked how he did it. He stated that it was "this place" that had helped him. When asked what in particular had helped him, he stated, "the computers and thinking to myself that I can do it. Then when I get it right I tell myself I did a good job and to do it next time." One year following treatment, Sam remembered significant steps in the cognitive training without prompting, and attributed his success in school to his having followed them.

Don

Don was referred to the summer school program with a severe learning disability which was related to deficiencies in both auditory and visual abstract abilities. In the last few years, he had been tracked into classes at the home school for the educable mentally handicapped.

He was observed by his trainer and his summer school teachers to be highly preoccupied and distractible, even in one-to-one tutoring. On several items of the teacher-completed classroom behavior rating scale having to do with distractibility and speed of work, Don showed important progress over the six week period of the study. These advances were also noted by his trainer, who was struck with how evidence of success in the lab--getting a right answer on the computer math game, hearing encouragement from the trainer, receiving a star--would be met by Don with broad grins of satisfaction and renewed attention to his work. In the cognitive training, Don was observed to make significant advances in the self-evaluation step, eventually able to follow accurate performance with emphatic statements of self-praise.

Don was observed in training sessions to be socially withdrawn and, at first, somewhat intimidated by the training program. Don was observed to relax into the routine over the first two weeks, however, and and he began to build relationships in the laboratory, especially with his trainer. The trainer and the experimenter saw this relationship as a crucial component in his progress.

On the classroom word problems administered in the fifth week he got three correct out of three attempts, an important event for Don, regardless of whether this was a result of the training or the classroom instruction. In all of his academic performance measures, Don showed an increase in productivity, which was an important gain for this highly distractible child. Don's academic performance and behavioral data were showing improving trends at the conclusion of the project. A longer period of training and data collection appears to be necessary in order to find the limits of these effects.

When asked at the end of training what he liked about it, Don said, "StickyBear" (the character used in the scenes on his computer math game).

Cal

Cal was referred to the summer school program with the home school reporting that he was behind in reading achievement, with a mild to moderate learning disability. He was noticed to have a slight articulation problem which made his speech sound like that of a child about five years old. On his admission to the summer school program he was observed by the program's director to be depressed, possibly as a result of a strong negative support system in his family. His classroom teacher in the summer school program observed that Cal performed best when math problems were presented as part of a game, and worst when they came in the context of a quiz. This was perhaps due to an aversion to any task he more readily associated with evaluation, since evaluation may have become a negative experience.

Cal, who spoke of having a microcomputer, expressed a high degree of interest in its use. This level of interest was consistent with his having performed well on the computer math game. He showed genuine glee at certain of the sound and graphics feedback, and did not tire of them as the older Wes and Sam were observed to do. When asked at the end of training what he liked about it, Cal said, "The computers."

It was realized late in the training that Cal would have benefited more from daily rather than weekly reinforcement. His performance increased when such a modification of his reinforcement regime was made, lending credibility to this assumption.

While true of all the subjects, Cal clearly could have benefited from an extended period of training. His avoidance of frustration by failing to apply himself appeared to be a well-established pattern. Toward the end of the study, Cal's classroom teacher began to rate him more positively for staying with problems and seeking help when frustrated. This was one of the most important accomplishments with Cal, who radically changed his pattern of skipping numerous problems on his worksheets, making attempts at most problems instead.

Cal had gaps in his knowledge of the multiplication tables. While the random number generators used in the study selected the numbers five and six as multiplication factors at the same rate, Cal did not, avoiding problems that asked him to multiply by six. Both to his teacher and to his trainer, his work quickly revealed difficulties with certain numbers as factors. Especially during baseline he rapidly went through multiple quiz sheets, specifically selecting problems in which only the numbers one through five appeared. This pattern was also evident in the cognitive training and was a major focus of that intervention. But while the training was showing the effect of Cal spending more time with a problem, concentrating better, and even beginning to check his work, it did not teach him multiplication facts and he began consistently failing the items he had previously skipped. Cal had found himself in a bind: in order to improve performance on the problems to which he was newly attending, he would also have to improve the attention he was giving to his teacher during instruction. In the final two weeks of summer school his teacher did, in fact, begin reporting behavioral ratings showing improvements in Cal's attending to her instruction.

The clear lesson for improving academic performance is that, while instruction is not possible without the attending behavior of the child, attending behavior is meaningless in itself without instruction. The present findings may be useful in designing intervention programs which would propose to improve the school performance of the A.D.D. child. Programs are more likely to succeed if they provide A.D.D. children with the information, the structure, and the encouragement they need to be able to accomplish academic tasks. Helping them learn how to focus their abilities and setting them up for success experiences may be instrumental to the success of such an approach.

Conclusions

A long tradition of research has shown that positive reinforcement for a behavior can increase that behavior. This has been extended to populations of A.D.D. children, as well (e,g., Rapport et al, 1980; Pelham et al, 1986; and Sindelar et al, 1982). It was not surprising, therefore, that the present study recorded a positive effect on academic performance measures that were reinforced. While there have been no previous reports in the literature of reinforcement criteria showing experimental control over a subject's performance on a computer math game, such an effect is reported here. Within the context of this study, the major importance of these two findings is that they provide evidence that the subjects engaged in the training program and had rewarding experiences working math problems.

A more significant finding was the generalization of the training effects to the non-reinforced measures, both academic and non-academic. While the influence of the initiation of training can be seen in the results of the CPT, how this influence helps reduce errors in responding on the CPT is not clear. A look at the nature and context of the CPT task may help in understanding how the generalization of skills occurred.

One possibility is that motivation to do well on any task presented in the laboratory increased as the training experience became more enjoyable. Another possibility is that the subjects were discovering their capabilities during the reinforced task. Improvements in nonreinforced tasks may have been facilitated by an increase in the subjects' appraisal of the likelihood of their success based on their having proven their ability on the reinforced task.

A third possibility is that in the process of improving their attentional behavior during the variety of tasks in this study, the subjects strengthened certain supportive abilities. These could include maintaining a relatively fixed line of sight, blocking out distracting thoughts, discriminating between relevant and irrelevant stimuli, attending to the relevant stimuli, persevering on difficult tasks, asserting control over motor impulses, recognizing sequencing of critical aspects of problems, engaging in self-evaluation, and making commitments to performance goals.

With these skills strengthened they were then more available to be called upon during the CPT. They would, as well, be available for the subject to use in other situations, but the subject would have to recognize their applicability. Gaining facility in making such associations was one of the primary goals of the cognitive training. Seeing that a behavior is called for in a particular situation, however, does not guarantee that it will be used. Going one step further, then, the cognitive training also specifically worked with the subject on associating attention deployment and impulse control with success and with experiences of positive self-regard.

The cognitive training was designed to encourage the transfer of the skills gained in training. Whether or not it was in fact responsible for the observed transfer has not been shown here. Further research is needed to separate the effects of the various components of the treatment package used in this study.

The more important objective of this study was to generalize the positive effect of the training to include improved performance in the classroom. The improvements Don and Wes showed in the classroom could reasonably have been expected to continue if the study had been longer than six weeks, showing a stronger effect. Sam, on the other hand, did not show training effects in the classroom despite clearly significant generalization across tasks in the lab. A characteristic pattern of the improvements show that, while it is difficult to eliminate the typical inconsistency of the A.D.D. child's performance in six weeks, it is reasonable to expect that the positive swings will reach higher levels.

The A.D.D. child has often developed a patterned expectation of frustration and failure (Douglas & Peters, 1979). A positively patterned and self-controlled response to problems can be taught to A.D.D. children, helping to shape an expectation that effort will be accompanied by success. When they have the opportunity to practice self-control skills in rewarding encounters with problems that are within the range of their abilities, and when at the same time they are challenged within a supportive, performance-oriented environment, they can be expected to improve their performance on related or even unrelated tasks.

Of all the attempts to remediate the deficits of A.D.D., the contingency management approach has shown the strongest results, but it has the limitation of not showing either a transfer of training effects across behaviors nor a maintenance of the response after the treatment has ended (Bornstein & Hamilton, 1975; Ferritor et al., 1972; Kazdin & Bootzin, 1972; O'Leary & Kent, 1973). The results of the present study suggest that this lack of generalization of skills is not because the A.D.D. syndrome limits the child's ability to generalize skills across tasks or situations. To the contrary, the A.D.D. child does show a capacity for generalizing skills, e.g, those needed to improve classroom performance. Four conditions appear to be necessary for this generalization to occur, however. First, the A.D.D. child must be taught how to recognize the common features of situations in which particular skills would serve them. Second, the

A.D.D. child must be taught how to interrupt patterned responses of impulsivity and inattention with new patterns of self-directed control. Third, the A.D.D. child must see a reason to expect success in the use of relevant skills. Fourth, in the absence of the extrinsically derived reinforcement that accompanies contingency management, A.D.D. children must learn to manage their own motivation through self-evaluation.

Generalization of skills appears to be influenced by the quality of the interactions in training and the content of the training stimuli. Kendall and Braswell (1985) have pointed to the need for cognitive training to be interactive, flexible, and tailored to the level of the child. Kendall and Wilcox (1980) demonstrated that cognitive training is more likely to achieve a generalization of effects to the classroom when the labeling of problem-solving steps moves from the more concrete to the conceptual.

The present study has shown that a computer-assisted treatment package that contains contingency management, cognitive training, and a positive trainer-trainee relationship can obtain a transfer of effect to other, non-reinforced measures. To a lesser extent, and for only two of the four subjects, the effect was also observed in the classroom of the summer program. This latter conclusion must be made cautiously given that (a) the experimental and control subjects were not matched pairs, and (b) the controls did not receive the same amount of attention as the experimental subjects.

In the classroom, only academic performance was affected. On-task behavior was not significantly affected. This finding differs from that of Bornstein and Quevillon (1976) where subjects responded to laboratory treatment with improved on-task behavior in class. Possible reasons for this include artifacts in the observational system of this study, differences in the environmental contingencies of the classroom, and differences in the content of the cognitive training. Where this study used math problems to train self-instruction, Bornstein and Quevillon (1976) used the types of social situations the child might face in the classroom.

Kendall and Braswell (1985), in their discussion of the failure of Friedling and O'Leary (1979) to replicate the Bornstein and Quevillon (1976) data, suggest that the replication study's failure to include a reinforcement component was critical in the two studies arriving at differing results. A possible reason for the success of combining a cognitive-behavioral approach with contingency management is that the A.D.D. child needs a reinforced situation in order to be motivated to try out the skills gained in cognitive training. Without practice in such a rewarding situation, the child fails to recognize the concrete advantages of using the skills and they remain undeveloped or are lost. On the other hand, the child is more likely to try attention skills in new situations if he learns, (a) through contingency management, that use of these skills can occasion rewards and, (b) through cognitive training, that he can reward himself with positive self-evaluation.

It is possible that cognitive training provides children with templates for behavior which they can use in sets of similar situations. The reinforcement, in its turn, provides the subject with both the reason to try out the templates to see if they work and the practice needed to make them work.

Clearly, interventions for the A.D.D. child must be tailored to the particular needs of each child. Such a call for individualized treatment is being repeated with increasing frequency (e.g., Brown et al., 1986; and Whalen, Henker, & Henshaw, 1985) as research continues to show idiosyncratic responses to experimental interventions.

Recommendations for Further Research

There are numerous possibilities for following-up and improving on this study. Mentioned here are recommendations which would improve collection of observational data, address the problem of matching pairs, and investigate the relative roles of the components of the treatment package.

Observation of both instructional and test periods could produce data to be analyzed separately. Correlations could be looked for between the daily variations of the academic measures and the daily variations of the behavioral measure. It would interesting to discover whether or not on-task behavior is directly correlated with academic measures. Normative data would be helpful in these determinations, investigating the extent to which on-task behavior and academic performance are a function of the nature and difficulty of the tasks. The behavior of A.D.D. children could be better interpreted in comparison to these norms.

A design feature could be used to address the question of the extent to which the content of the problems used in the cognitive training is significant in yielding generalization to different types of tasks. Subjects receiving cognitive training could be divided into two groups, one that works with academic tasks in the practice of the self-instruction steps and one that uses social situations similar to those in the Bornstein and Quevillon (1976) study. One would expect to see group differences in the amount of improvement in classroom academic performance and on-task behavior.

Further research using group comparison designs could address problems of a) the amount of attention received by experimental versus control subjects and b) the degree to which the controls are matched with the experimental subjects. Controls could receive an equivalent amount of adult attention by meeting at the same time as the experimental group and becoming involved in activities not designed to improve their academic performance or on-task behavior. The use of A.D.D. subjects for no-treatment matched controls raises ethical problems due to indications in the present study that the treatment is helpful. The problem of truly matching pairs is, therefore, one that is difficult to overcome outside of the multiple baseline approach used in this study. One possible solution within a group comparisons design would be comparing the effects of the treatment package of the current study to the effects of another treatment approach, however, using matched pairs. Another solution would be a delayed treatment approach where controls were provided treatment at the conclusion of the study.

In the lab, one could compare the components of the treatment package to try to find what types of training are more effective with what types of children. The CPT, for example, could be given to two groups: one group that was trained with the present treatment package including the computer math game and computer-assisted cognitive training, and another group whose treatment package used a math board-game and math worksheets in place of the computer. Another approach would be to have a multiple baseline across treatments. In this design, some A.D.D. subjects would have reinforcement following baseline, with the addition of the cognitive training to come later. Other subjects would have the cognitive training withheld for the entire study. Still others would have alternating treatments, leaving the cognitive training in place while introducing and withdrawing the behavioral reinforcement component.

The role of social reinforcement within the group of experimental subjects, while it appeared to work favorably toward a positive outcome, needs to be investigated further. Performance of subjects trained in a strictly individual setting could be compared to subjects trained in a small group setting such as the one used in the current study. This comparison could also help to discern the extent of any interdependence of the data collected from subjects trained in a group setting.

A final recommendation is directed toward a study of environmental variables and the quality of the classroom experience. All subjects could be provided with the same laboratory training, while classroom factors are varied in an attempt to discover which classroom factors enhance generalization of training. This could include direct observation of both the teacher and the student. The resulting data could prove useful in analyzing the behavior of the student as a factor of the attention received from the teacher, and help to identify the role of other classroom contingencies in the improvement of academic performance and on-task behavior.

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APPENDIX A

PROCEDURE FOR IDENTIFICATION OF A.D.D. SUBJECTS

USE OF THE SELF-CONTROL RATING SCALE IN IDENTIFICATION OF A.D.D.

The Self-Control Rating Scale was selected for purposes of subject selection. This was done because the instrument has numerous items which concretely describe the "symptoms," or descriptors, necessary for a DSM III diagnosis of A.D.D.

The overlap of the items of the Self-Control Rating Scale and the descriptors of the DSM III diagnosis is not complete. Four items of the rating scale were not used in subject selection. Two of those items (#3 and #12) would be helpful in identifying hyperactivity, but the two items were not seen as sufficient for that role in themselves. Items #15 and #19 do not clearly fit into the DSM III framework and were not used for A.D.D. identification. As well, no item on the Self-Control Rating Scale addresses the DSM III descriptor, "frequently calls out in class."

Following in this appendix are two documents which were used in the process of subject selection. The first is a copy of the rating scale showing the scale of one through seven for each item, with a rating of four representing how the rater would rate the "average child" on the item. Following the rating scale is an outline showing each DSM III A.D.D. discriptor in uppercase with the relevant item(s) from the Self-Control Rating Scale listed beneath it. For a subject to be identified as attention deficient, three of the four "inattention" descriptors and three of the five "impulsivity" descriptors had to be rated as positive. For a rating to be considered positive, the mean rating for all items under the descriptor had to average five or above.

Name of Child ______________________ Grade ______
Rater ______________________

Please rate this child according to the descriptions below by circling the appropriate number. The underlined 4 in the center of each row represents where the average child would fall on this item. Please do not hesitate to use the entire range of possible ratings.

1. When the child promises to do something, can you count on him/her to do it?	1 2 3 <u>4</u> 5 6 7	always ... never
2. Does the child butt into games or activities even when he/she hasn't been invited?	1 2 3 <u>4</u> 5 6 7	never ... often
3. Can the child deliberately calm down when he/she is excited or all wound up?	1 2 3 <u>4</u> 5 6 7	yes ... no
4. Is the quality of the child's work all about the same or does it vary a lot?	1 2 3 <u>4</u> 5 6 7	same ... varies
5. Does the child work for long-range goals?	1 2 3 <u>4</u> 5 6 7	yes ... no
6. When the child asks a question, does he/she wait for an answer, or jump to something else (e.g., a new question) before waiting for an answer?	1 2 3 <u>4</u> 5 6 7	waits ... jumps
7. Does the child interrupt inappropriately in conversations with peers, or wait his/her turn to speak?	1 2 3 <u>4</u> 5 6 7	waits ... interrupts
8. Does the child stick to what he/she is doing until he/she is finished with it?	1 2 3 <u>4</u> 5 6 7	yes ... no
9. Does the child follow the instructions of responsible adults?	1 2 3 <u>4</u> 5 6 7	always ... never
10. Does the child have to have everything right away?	1 2 3 <u>4</u> 5 6 7	no ... yes
11. When the child has to wait in line, does he/she do so patiently?	1 2 3 <u>4</u> 5 6 7	yes ... no
12. Does the child sit still?	1 2 3 <u>4</u> 5 6 7	yes ... no
13. Can the child follow suggestions of others in group projects, or does he/she insist on imposing his/her own ideas?	1 2 3 <u>4</u> 5 6 7	able to follow ... imposes
14. Does the child have to be reminded several times to do something before he/she does it?	1 2 3 <u>4</u> 5 6 7	never ... always

15. When reprimanded, does the child answer back inappropriately?	1 never	2	3	4	5	6	7 always
16. Is the child accident-prone?	1 no	2	3	4	5	6	7 yes
17. Does the child neglect or forget regular chores or tasks?	1 never	2	3	4	5	6	7 always
18. Are there days when the child seems incapable of settling down to work?	1 never	2	3	4	5	6	7 often
19. Would the child more likely grab a smaller toy today or wait for a larger toy tomorrow, if given the choice?	1 wait	2	3	4	5	6	7 grab
20. Does the child grab for the belongings of others?	1 never	2	3	4	5	6	7 often
21. Does the child bother others when they're trying to do things?	1 no	2	3	4	5	6	7 yes
22. Does the child break basic rules?	1 never	2	3	4	5	6	7 always
23. Does the child watch where he/she is going?	1 always	2	3	4	5	6	7 never
24. In answering questions, does the child give one thoughtful answer, or blurt out several answers all at once?	1 one answer	2	3	4	5	6	7 several
25. Is the child easily distracted from his/her work or chores?	1 no	2	3	4	5	6	7 yes
26. Would you describe this child more as careful or careless?	1 careful	2	3	4	5	6	7 careless
27. Does the child play well with peers (follow rules, wait turn, cooperate)?	1 yes	2	3	4	5	6	7 no
28. Does the child jump or switch from activity to activity rather than sticking to one thing at a time?	1 sticks to one	2	3	4	5	6	7 switches
29. If a task is at first too difficult for the child, will he/she get frustrated and quit, or first seek help with the problem?	1 seek help	2	3	4	5	6	7 quit
30. Does the child disrupt games?	1 never	2	3	4	5	6	7 often
31. Does the child think before he/she acts?	1 always	2	3	4	5	6	7 never
32. If the child paid more attention to his/her work, do you think he/she would do much better than at present?	1 no	2	3	4	5	6	7 yes
33. Does the child do too many things at once, or does he/she concentrate on one thing at a time?	1 one thing	2	3	4	5	6	7 too many

ASSIGNMENT OF SELF-CONTROL RATING SCALE ITEMS

TO DSM III DESCRIPTORS FOR A.D.D.

I. INATTENTION

OFTEN FAILS TO FINISH THINGS

1. When the child promises to do something, can you count on him/her to do it?
5. Does the child work for long-range goals?
8. Does the child stick to what (s)he is doing until (s)he is finished with it?
14. Does the child have to be reminded several times to do something before (s)he does it?

OFTEN DOESN'T SEEM TO LISTEN

6. When the child asks a question, does (s)he wait for an answer, or jump to something else (e.g., a new question) before waiting for an answer?
9. Does the child follow the instructions of responsible adults?

EASILY DISTRACTED

25. Is the child easily distracted from his/her work or chores?

HAS DIFFICULTY CONCENTRATING ON SCHOOLWORK OR OTHER TASKS REQUIRING SUSTAINED ATTENTION

4. Is the quality of the child's work all about the same or does it vary a lot?
17. Does the child neglect or forget regular chores or tasks?
18. Are there days when the child seems incapable of settling down to work?
32. If the child paid more attention to his/her work, do you think (s)he would do much better than at present?

II. IMPULSIVITY

OFTEN ACTS BEFORE THINKING

31. Does the child think before (s)he acts?

SHIFTS EXCESSIVELY FROM ONE ACTIVITY TO ANOTHER

28. Does the child jump or switch from activity to activity rather than sticking to one thing at a time?
33. Does the child do too many things at once, or does (s)he concentrate on one thing at a time?

HAS DIFFICULTY ORGANIZING WORK

24. In answering questions, does the child give one thoughtful answer, or blurt out several answers all at once?
29. If a task is at first too difficult for the child, will (s)he get frustrated and quit, or first seek help with the problem?

NEEDS A LOT OF SUPERVISION

13. Can the child follow suggestions of others in group projects, or does (s)he insist on imposing his/her own ideas?
16. Is the child accident-prone?
20. Does the child grab for the belongings of others?
21. Does the child bother others when they're trying to do things?
22. Does the child break basic rules?
23. Does the child watch where (s)he is going?
26. Would you describe this child more as careful or careless?
30. Does the child disrupt games?

HAS DIFFICULTY AWAITING TURN IN GAMES OR GROUP SITUATIONS

2. Does the child butt into games or activities even when (s)he hasn't been invited?
7. Does the child interrupt inappropriately in conversations with peers, or wait his/her turn to speak?
10. Does the child have to have everything right away?
11. When the child has to wait in line, does (s)he do so patiently?
27. Does the child play well with peers (follow rules, wait turn, cooperate)?

APPENDIX B

LEVELS OF COMPUTATIONAL MATH DIFFICULTY, LAB AND CLASS

LEVELS OF COMPUTATIONAL MATH DIFFICULTY ON THE COMPUTER MATH GAME--ADDITION AND SUBTRACTION

Level 16: Two-place addition with carry, vertical presentation.

Level 17: Two-place subtraction with borrow, vertical presentation.

Level 20: Three-place addition and subtraction without carry or borrow, vertical presentation.

Level 21: Three-place addition with carry, vertical presentation.

Level 22: Four-place addition with multiple carry, vertical presentation.

Level 23: Three-place subtraction with borrow, vertical presentation.

LEVELS OF COMPUTATIONAL MATH DIFFICULTY ON THE

COMPUTER MATH GAME--MULTIPLICATION

Level 06: 8 and 9 as factors.

Level 08: Multiply three factors, all single digits, using the grouping theory.

Level 13: Use multiplication facts to find products of 10, 100, 1000.

Level 14: Multiply three factors when one factor is a multiple of 10, using grouping theory.

Level 15: Multiply one-digit factors by two-digit factors with or without trading 1's to find two-digit products.

Level 16: Multiply one-digit factors by two-digit factors with or without trading 1's and 10's to find three-digit products.

Level 17: Multiply three-digit factors by one-digit factors with one trade to find three- or four-digit products.

Level 18: Multiply one-digit factors by three- or four-digit factors with two or more trades or no trades writing products of three, four, or five digits..

Level 21: Multiply three- and four-digit factors containing 0's by one-digit factors to find four or five-digit products..

Level 23: Multiplying multiples of 10.

Level 27: Multiply two-digit numbers and two-digit numbers to find three- and four-digit products.

Level 28: Multiply three-digit numbers and two-digit numbers to find four- and five-digit products.

LEVELS OF COMPUTATIONAL MATH DIFFICULTY ON PENCIL AND PAPER TRAINING, LAB QUIZ, AND CLASSROOM MATH QUIZ

Level 0: Single-digit numbers with single-digit numbers without regrouping

Level 1: Single-digit numbers with single-digit numbers with regrouping

Level 2: Double-digit numbers with single-digit numbers without regrouping

Level 3: Double-digit numbers with single-digit numbers with regrouping

Level 4: Triple-digit numbers with single-digit numbers without regrouping

Level 5: Triple-digit numbers with single-digit numbers with regrouping

Level 6: Double-digit numbers with double-digit numbers without regrouping

Level 7: Double-digit numbers with double-digit numbers with regrouping

Assignments:

Cal... Level 3 multiplication

Don... Level 5 addition (first half of study)
Level 5 subtraction (second half of study)

Sam... Level seven multiplication

Wes... Level seven multiplication

APPENDIX C

SCHEDULES OF TRAINING AND MEASUREMENT

Cal

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
00	computer	pencil & paper	cognitive	(lab quiz)	meeting & CPT
15	pencil & paper	cognitive	(lab quiz)	computer	rewards
30	cognitive	(lab quiz)	computer	pencil & paper	
45	(lab quiz)	computer	pencil & paper	cognitive	
60					

Wes

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
00	pencil & paper	cognitive	(lab quiz)	computer	meeting & CPT
15	cognitive	(lab quiz)	computer	pencil & paper	rewards
30	(lab quiz)	computer	pencil & paper	cognitive	
45	computer	pencil & paper	cognitive	(lab quiz)	
60					

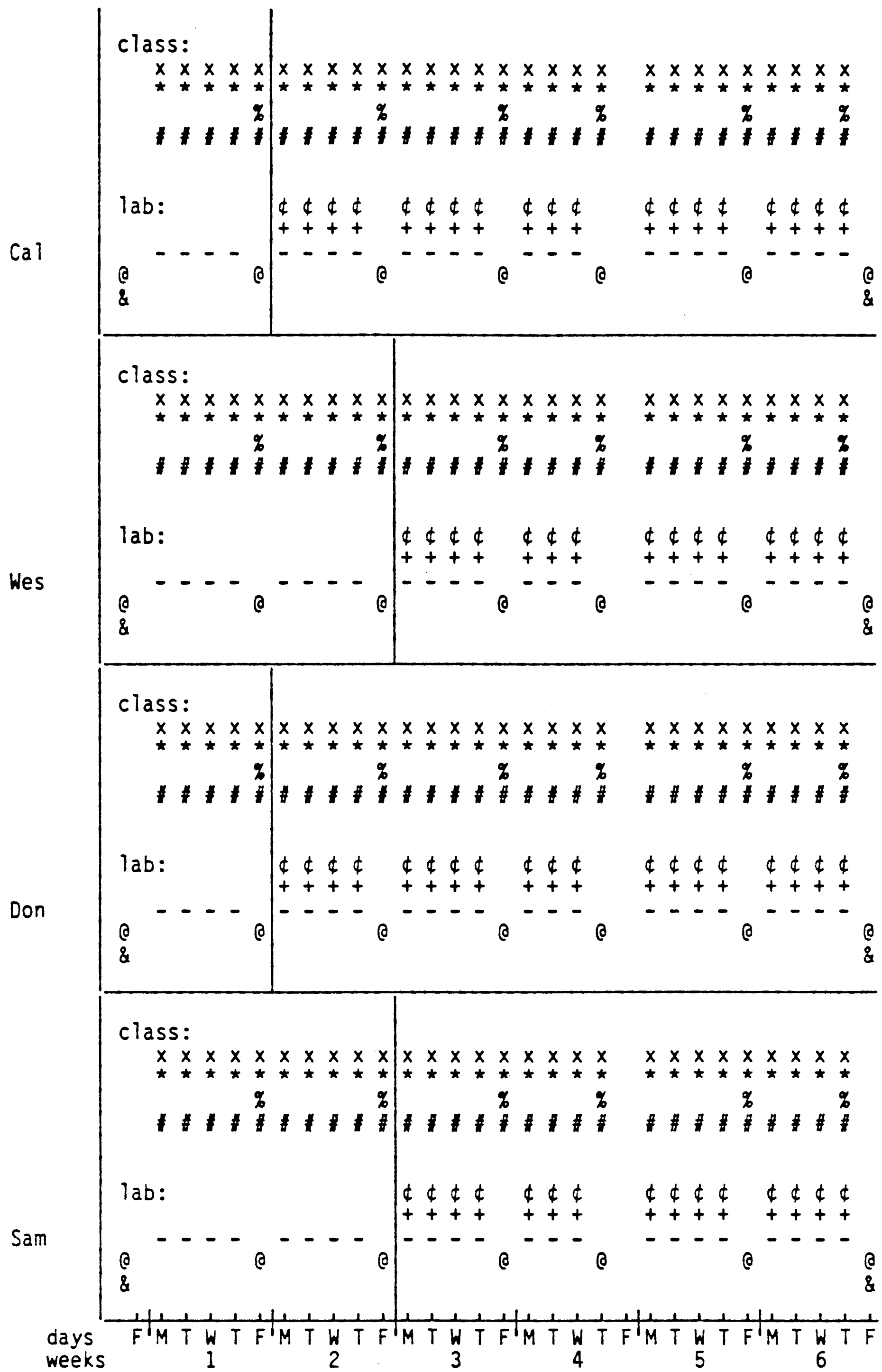
Don

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
00	cognitive	(lab quiz)	computer	pencil & paper	meeting & CPT
15	(lab quiz)	computer	pencil & paper	cognitive	rewards
30	computer	pencil & paper	cognitive	(lab quiz)	
45	pencil & paper	cognitive	(lab quiz)	computer	
60					

Sam

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
00	(lab quiz)	computer	pencil & paper	cognitive	meeting & CPT
15	computer	pencil & paper	cognitive	(lab quiz)	rewards
30	pencil & paper	cognitive	(lab quiz)	computer	
45	cognitive	(lab quiz)	computer	pencil & paper	
60					

Figure 1. Schedule for the training laboratory after baseline. The figures at left show minutes into the training hour. The "computer" training immediately rewarded performance on a computer math game with a choice of computer games. The "pencil & paper" training rewarded performance with tokens redeemable for prizes and reward activities on Fridays. The "cognitive" component was training in self-instructional problem solving using computer-presented math problems. The "lab quiz" was a pencil and paper measure without contingent reinforcement.



class:
behavioral observation = x
math quiz = *
word problems = %
teacher rating scale = #

laboratory:
computer training scores = ¢
pencil & paper training scores = +
lab quiz = -
CPT 2 = @   CPT 3 = &

Figure 2. Schedule for repeated measures showing multiple baselines across subject dyads. The KeyMath and the Self-Control Rating Scale are not shown. The solid vertical lines indicate onset of training.

APPENDIX D

LABORATORY DATA

TABLE V

ACQUISITION OF THE COGNITIVE TRAINING

		Daily Scores and Mean for the Week																		
S	Wk	Training Phase					Prob. Type				# of Problems					# of errors				
		M	T	W	T	X̄	M	T	W	T	M	T	W	T	X̄	M	T	W	T	X̄
Cal	2	1	1	2	2	**1.5**	A1	A1	A2	M1	8	4	7	3	**5.3**	01	04	02	06	**3.3**
	3	2	2	3	3	**2.5**	M1	M2	M1	M2	4	1	2	2	**2.3**	12	03	03	19	**9.3**
	4	3	3	4	-	**3.3**	M2	M2	M2	--	2	2	3	-	**2.3**	23	14	26	-	**21.0**
	5	4	4	5	5	**4.5**	M2	M2	M1	M2	2	4	9	5	**5.0**	12	09	25	22	**17.0**
	6	5	5	6	6	**5.5**	M1	M1	M2	M2	6	2	3	2	**3.3**	28	03	19	13	**15.8**
Wes	3	1	1	2	2	**1.5**	M1	M1	M2	M1	3	5	2	2	**3.0**	0	1	0	5	**1.5**
	4	1	2	3	-	**2.0**	M2	M2	M1	--	2	1	2	-	**1.7**	2	1	1	-	**1.3**
	5	2	3	3	4	**3.0**	D1	D2	D2	D2	3	1	2	2	**2.0**	0	0	0	0	**0.0**
	6	4	4	4	4	**4.0**	M2	M3	M3	D1	2	1	1	1	**1.3**	3	1	0	7	**2.8**
Don	2	1	1	2	2	**1.5**	A1	A2	S1	S1	6	12	2	4	**6.0**	1	5	2	3	**2.8**
	3	2	2	3	3	**2.5**	S1	S2	S2	S2	4	2	2	11	**4.8**	1	2	2	2	**2.8**
	4	3	3	4	-	**3.3**	S2	S2	S2	--	5	8	4	-	**5.7**	0	2	0	-	**1.3**
	5	4	4	5	5	**4.5**	S2	S2	S2	S2	2	6	4	4	**4.0**	2	2	1	2	**1.8**
	6	5	5	--	6	**5.3**	S2	S2	--	S2	6	5	-	18	**9.7**	0	1	-	4	**1.7**
Sam	3	1	1	2	2	**1.5**	M2	M2	M2	M2	2	1	3	2	**2.0**	2	6	1	1	**2.5**
	4	1	2	3	-	**2.0**	M2	M2	M2	--	2	1	3	-	**2.0**	3	0	1	-	**1.3**
	5	2	3	3	4	**3.0**	M2	M2	M2	M2	3	2	2	2	**2.3**	1	1	0	4	**1.5**
	6	4	4	4	4	**4.0**	M2	M2	M2	M2	3	2	2	1	**2.0**	2	2	9	2	**3.8**

Figures in boldface are means for the week. Don was late Wednesday of the sixth week and missed the cognitive training session that day.

Under Training Phase, the numbers represent phases in the training according to the following code:

1:Echo 2:Cue 3:Flash 4:Aloud 5:Whisper 6:Covert

Under Problem Type, the letter stands for either addition, subtraction, multiplication or division; the number stands for the number of digits in the second addend, the subtrahend, the multiplier, or the divisor.

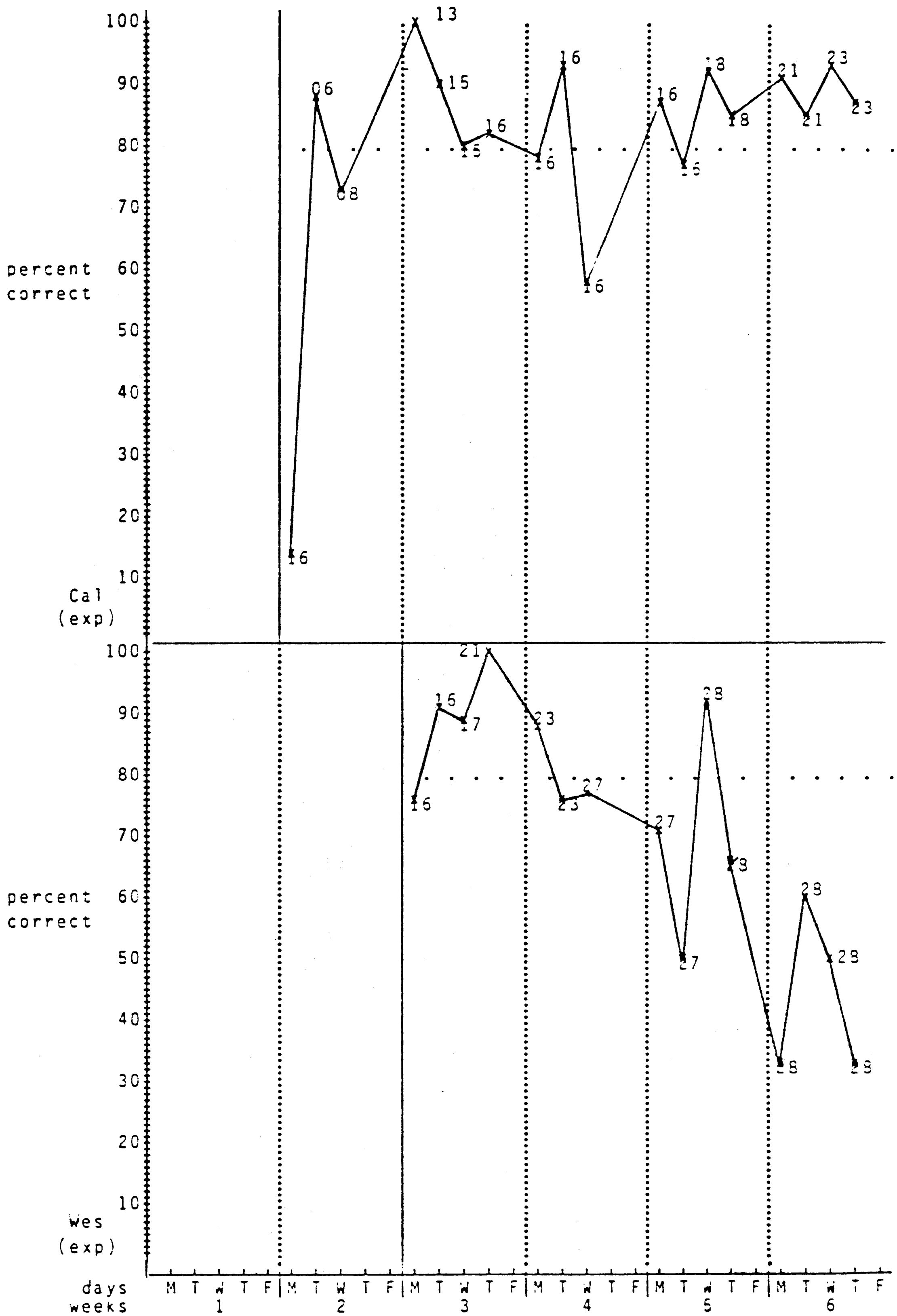


Figure 3.1. Percent correct on computer-presented problems: Cal and Wes. The level of difficulty is indicated near each data point. The criterion for reinforcement was 80 percent accuracy.

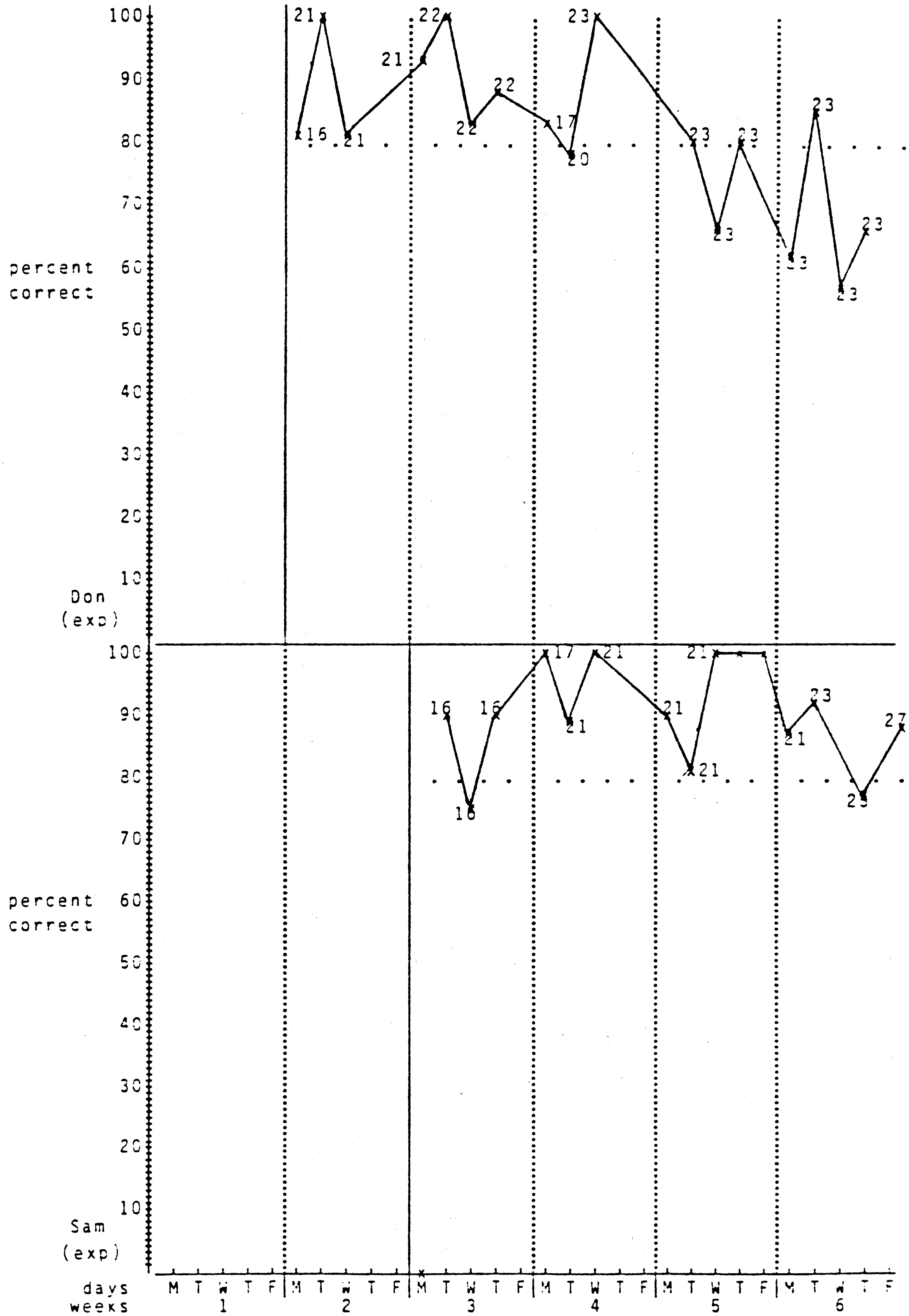


Figure 3.2. Percent correct on computer-presented problems: Don and Sam. The level of difficulty is indicated near each data point. The criterion for reinforcement was 80 percent accuracy.

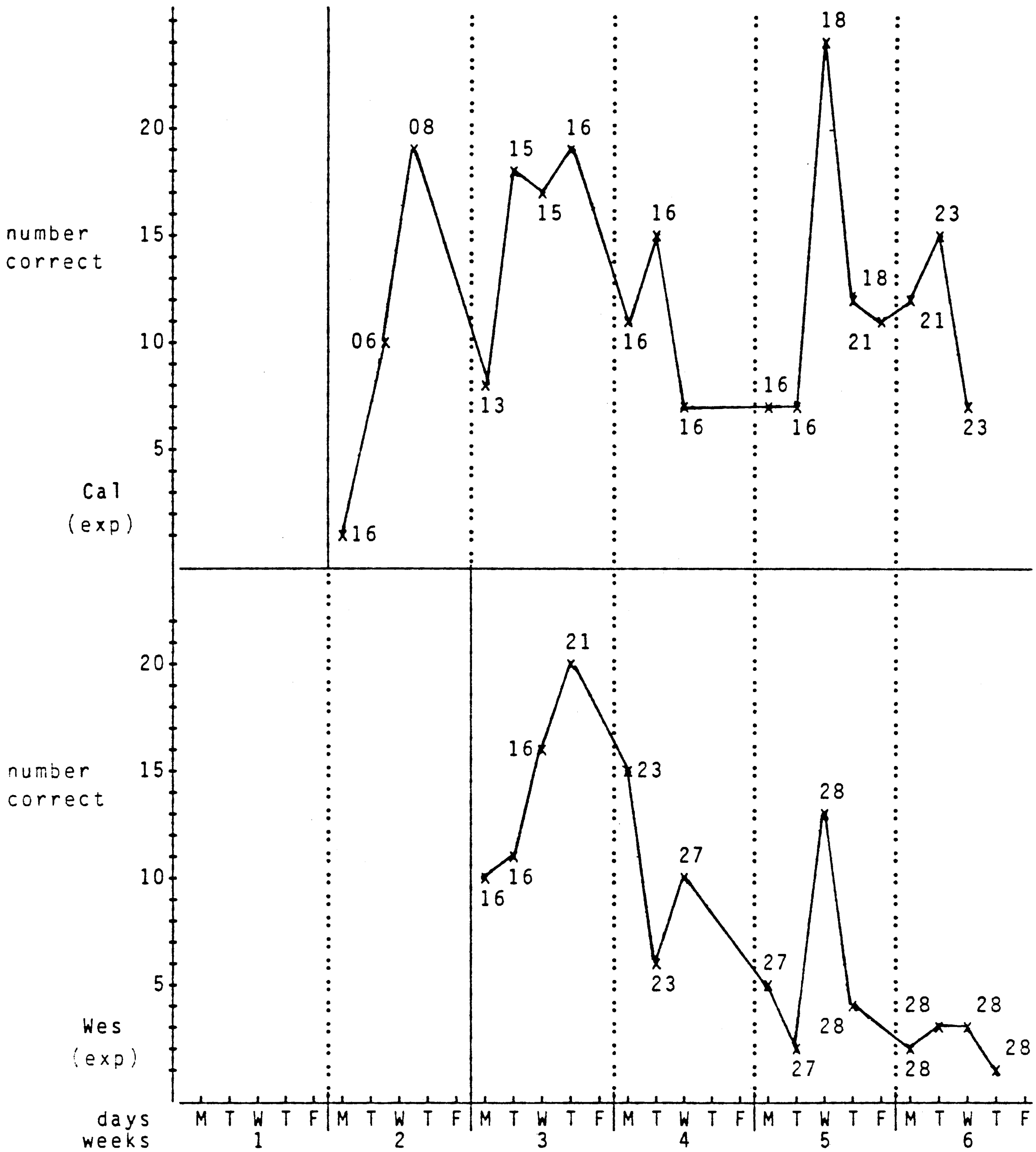


Figure 4.1. Number of correct responses on computer-presented problems: Cal and Wes. The level of difficulty is indicated near each data point.

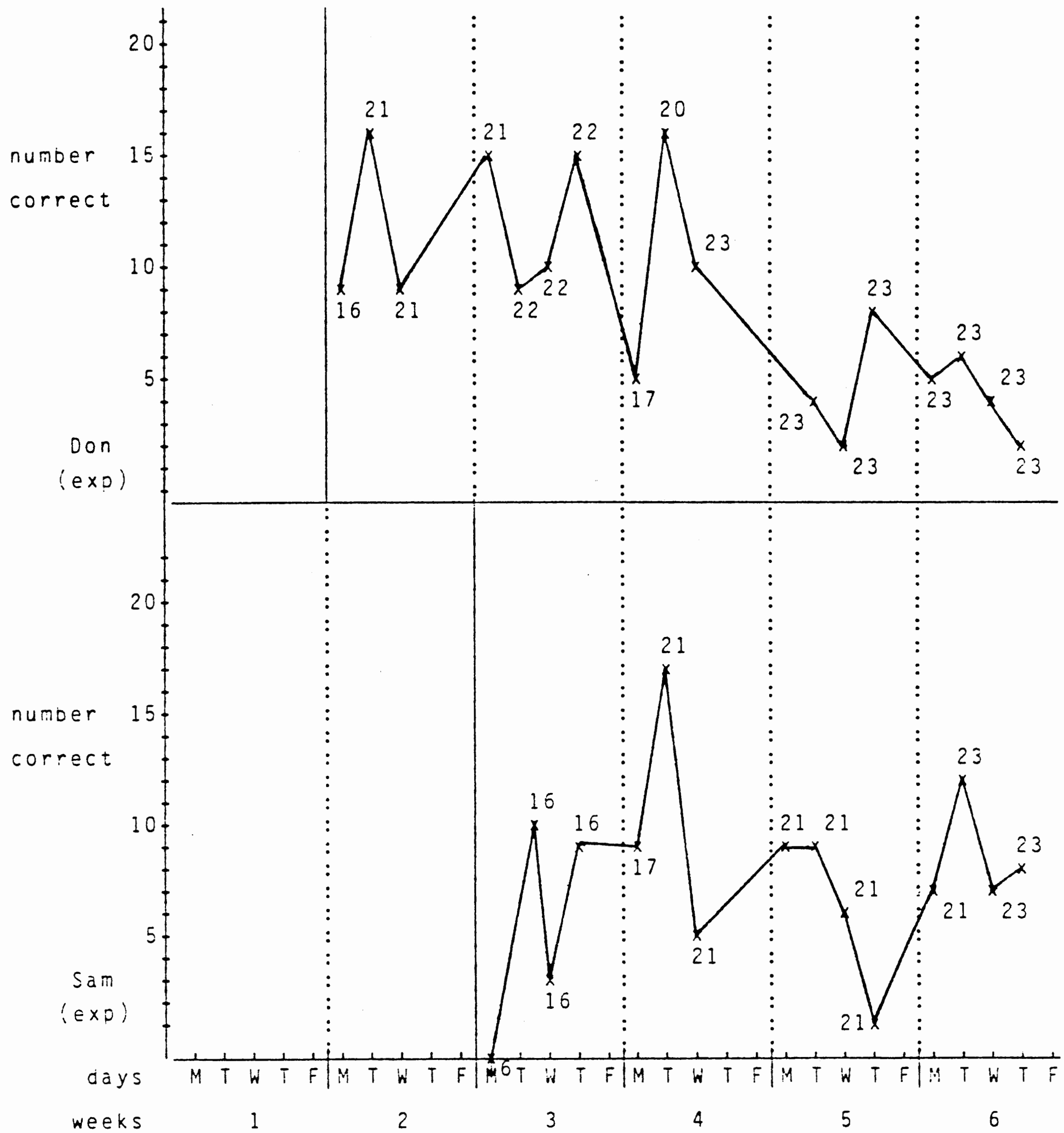


Figure 4.2. Number of correct responses on computer-presented problems: Don and Sam. The level of difficulty is indicated near each data point. Sam's trainer had problems with the computer on Thursday of the fifth week and he had only five minutes on the computer math game. Don was late on Monday of the fifth week and missed this training component.

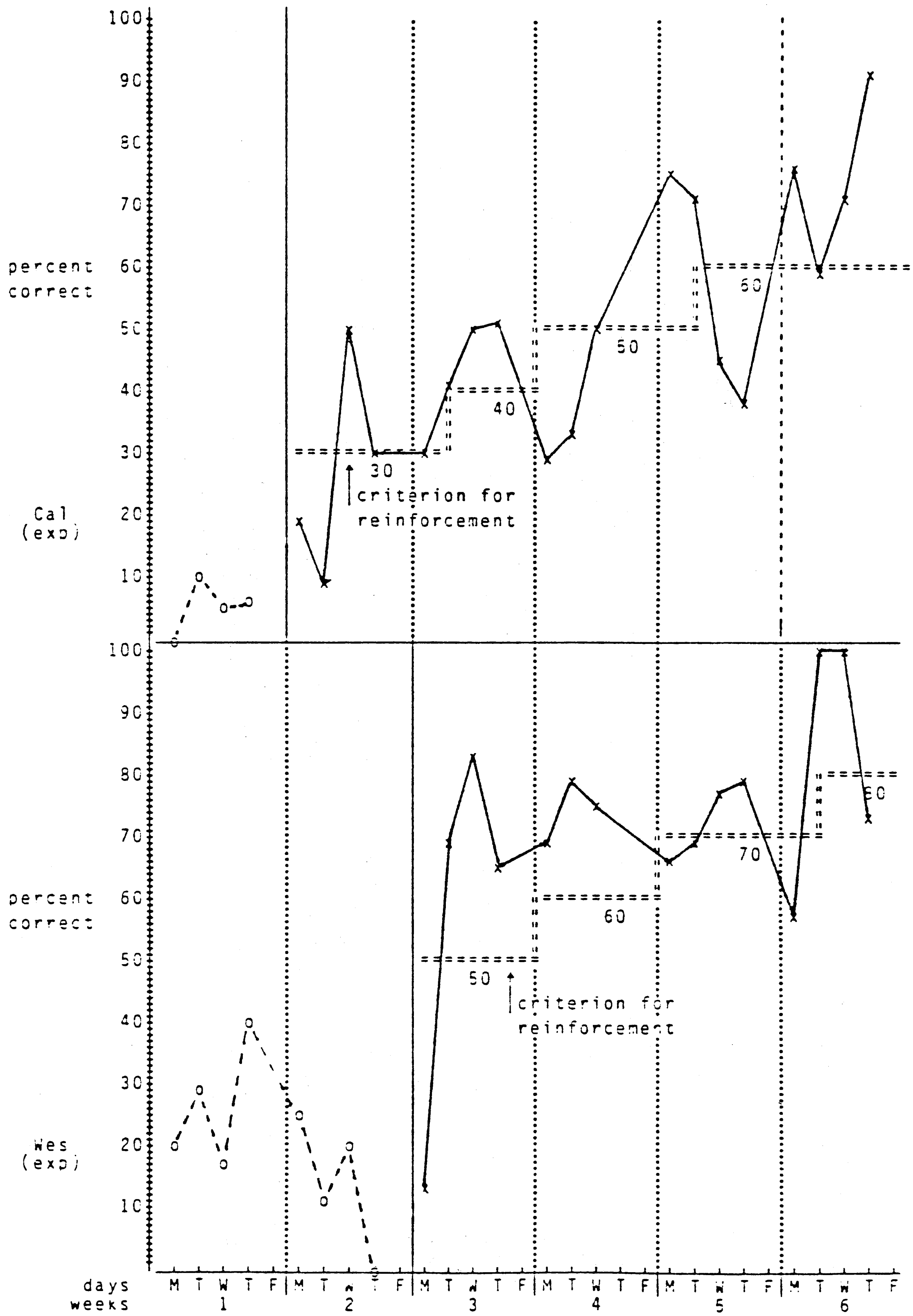


Figure 5.1. Percent correct on the paper and pencil task: Cal and Wes. The vertical dashed line between the fifth and sixth weeks indicates the point of modification in Cal's training.

o----o Data from lab quiz

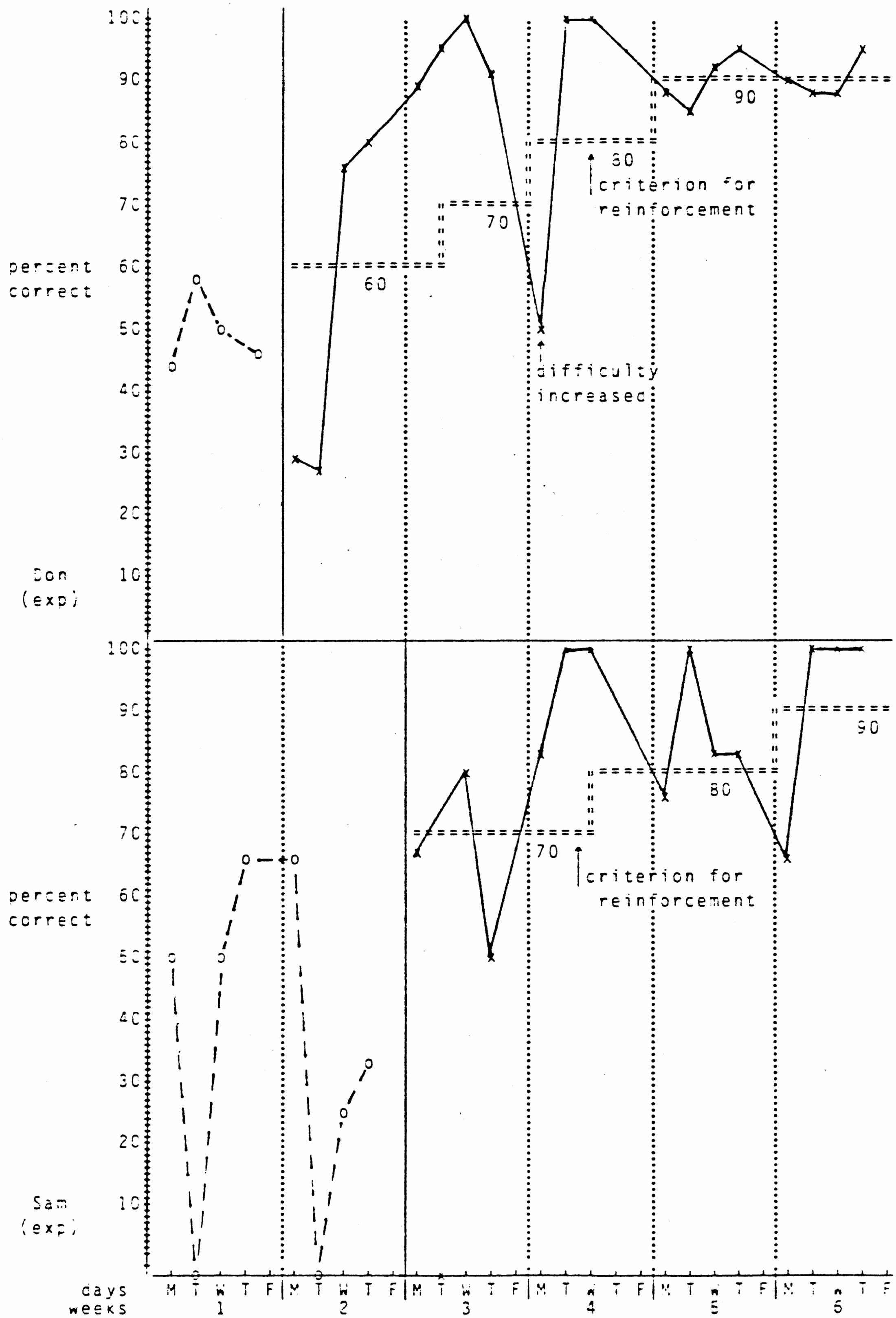


Figure 5.2. Percent correct on the paper and pencil task: Don and Sam.

o----o Data from lab quiz

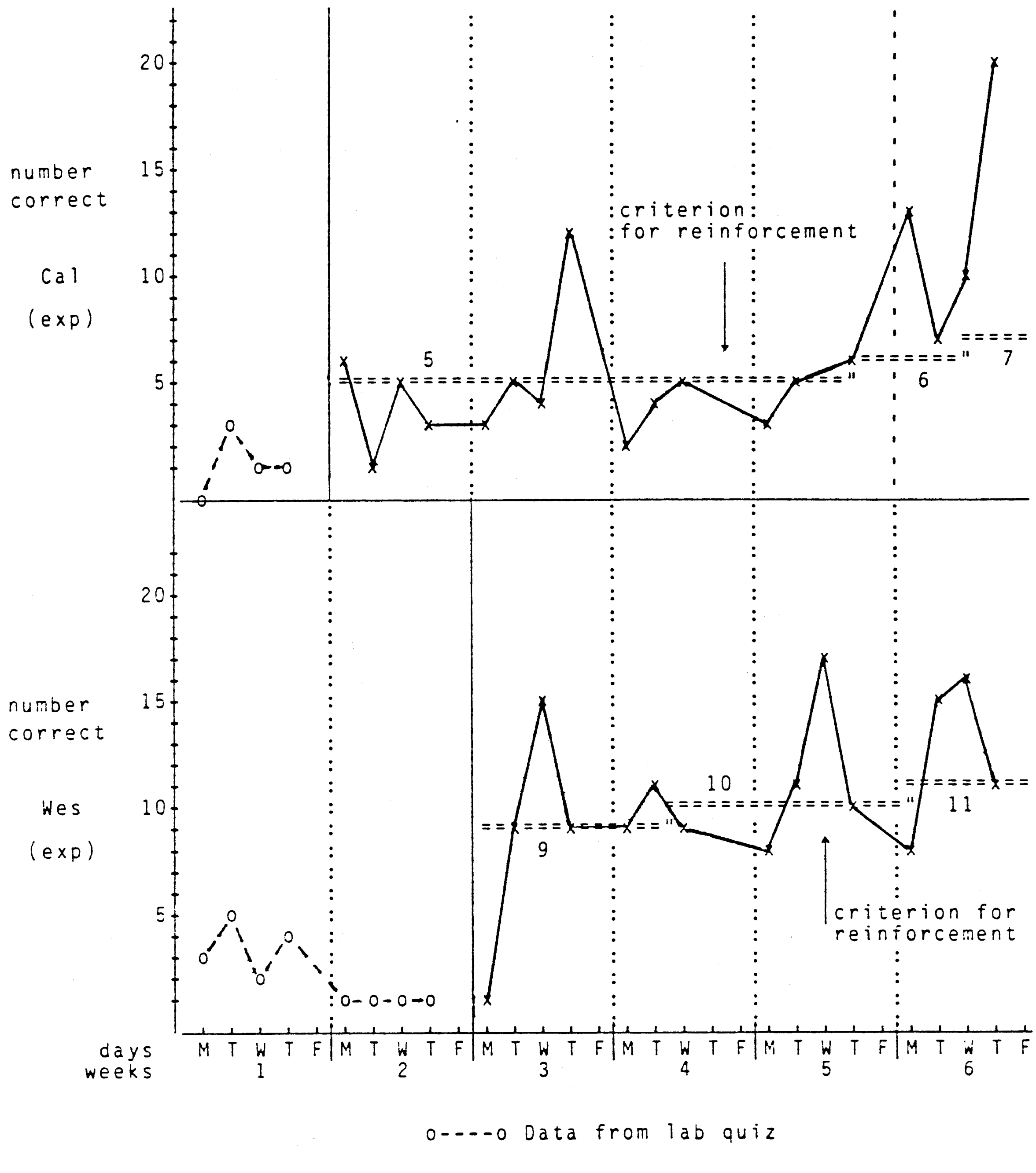


Figure 6.1. Number of correct responses on the pencil and paper task: Cal and Wes. The vertical dashed line indicates the point of modification in Cal's training.

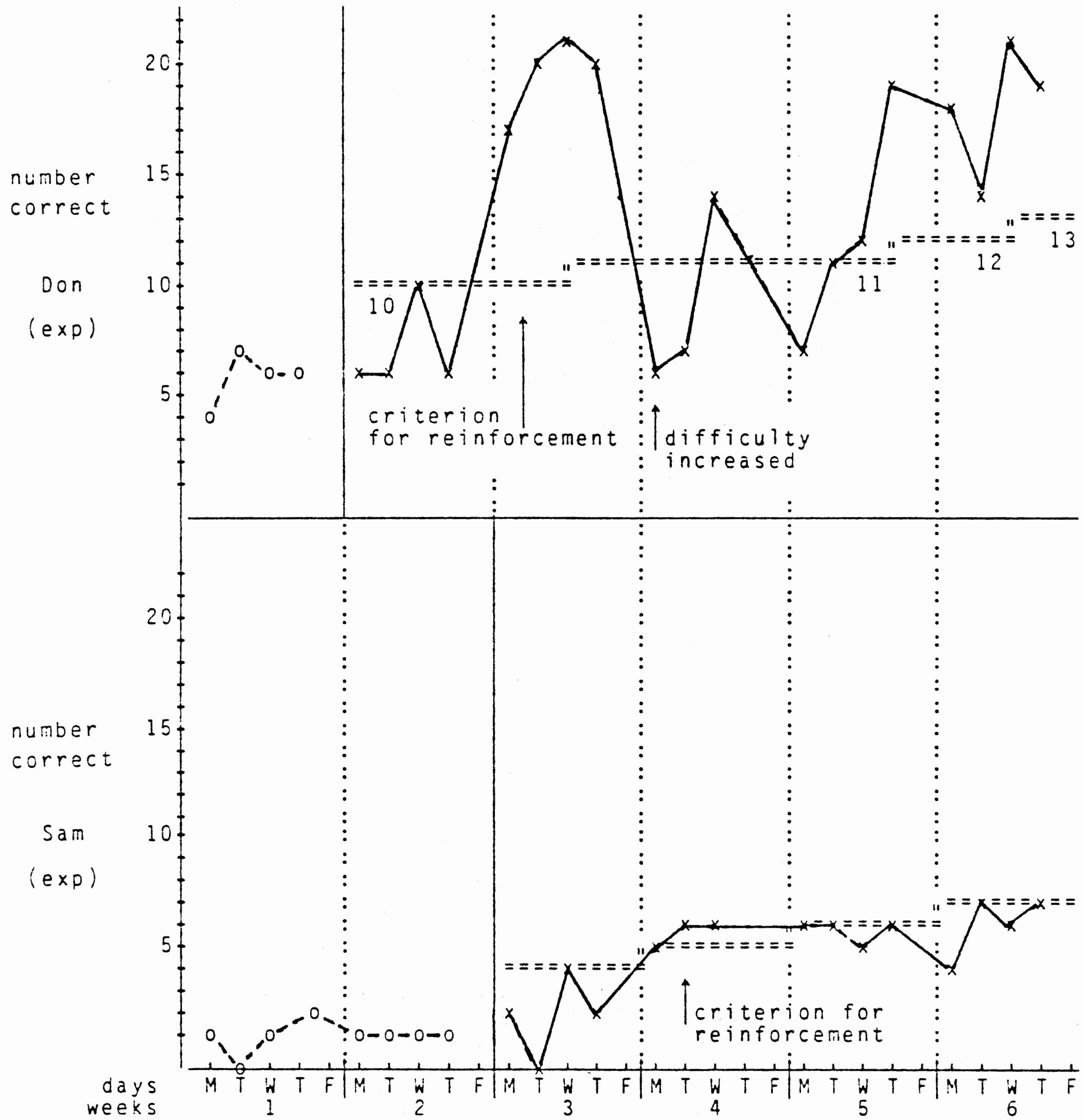


Figure 6.2. Number of correct responses on the pencil and paper task: Don and Sam.

o----o Data from lab quiz

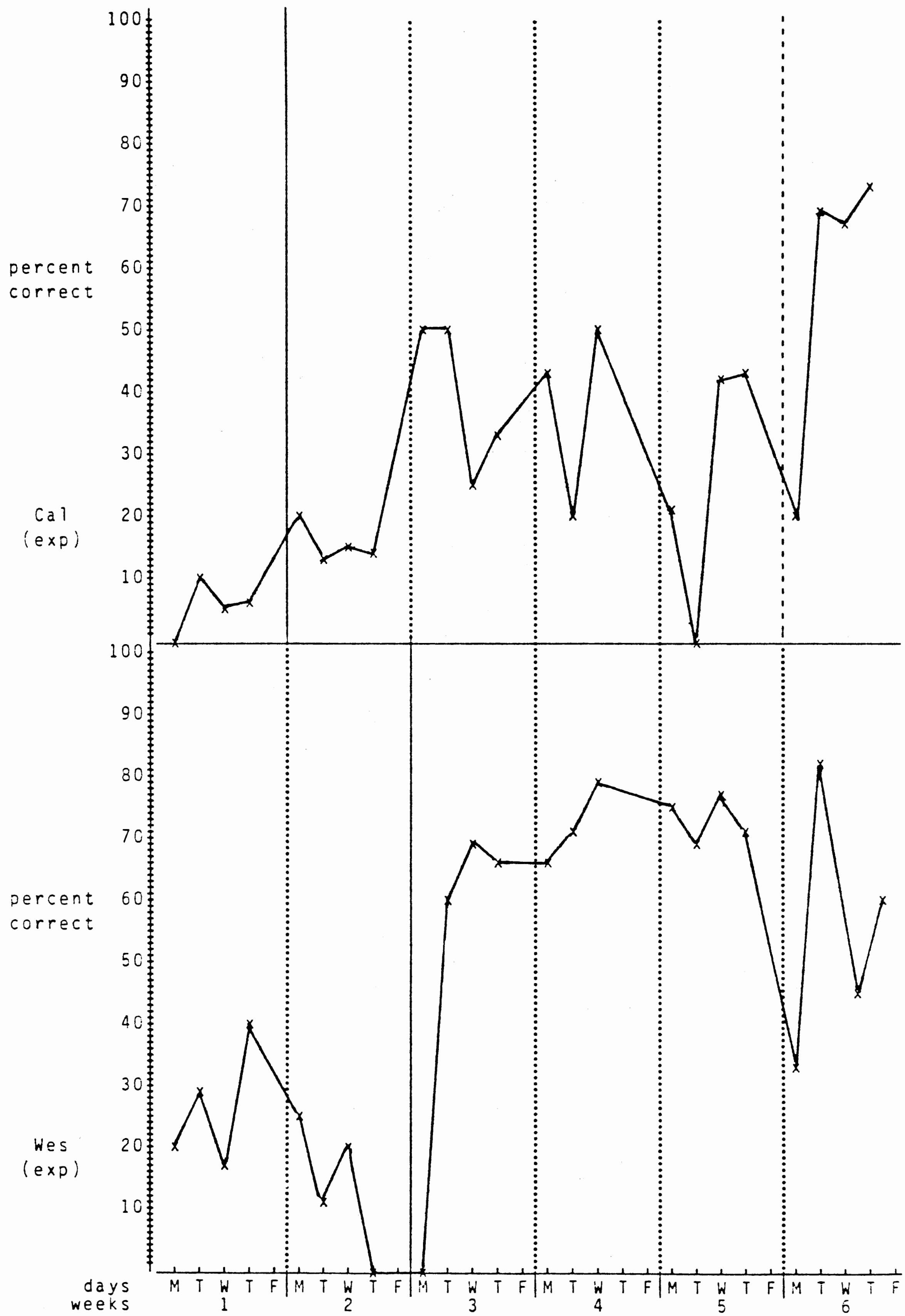


Figure 7.1. Percent correct during the lab quiz: Cal and Wes. The vertical dashed line indicates the point of modification in Cal's training.

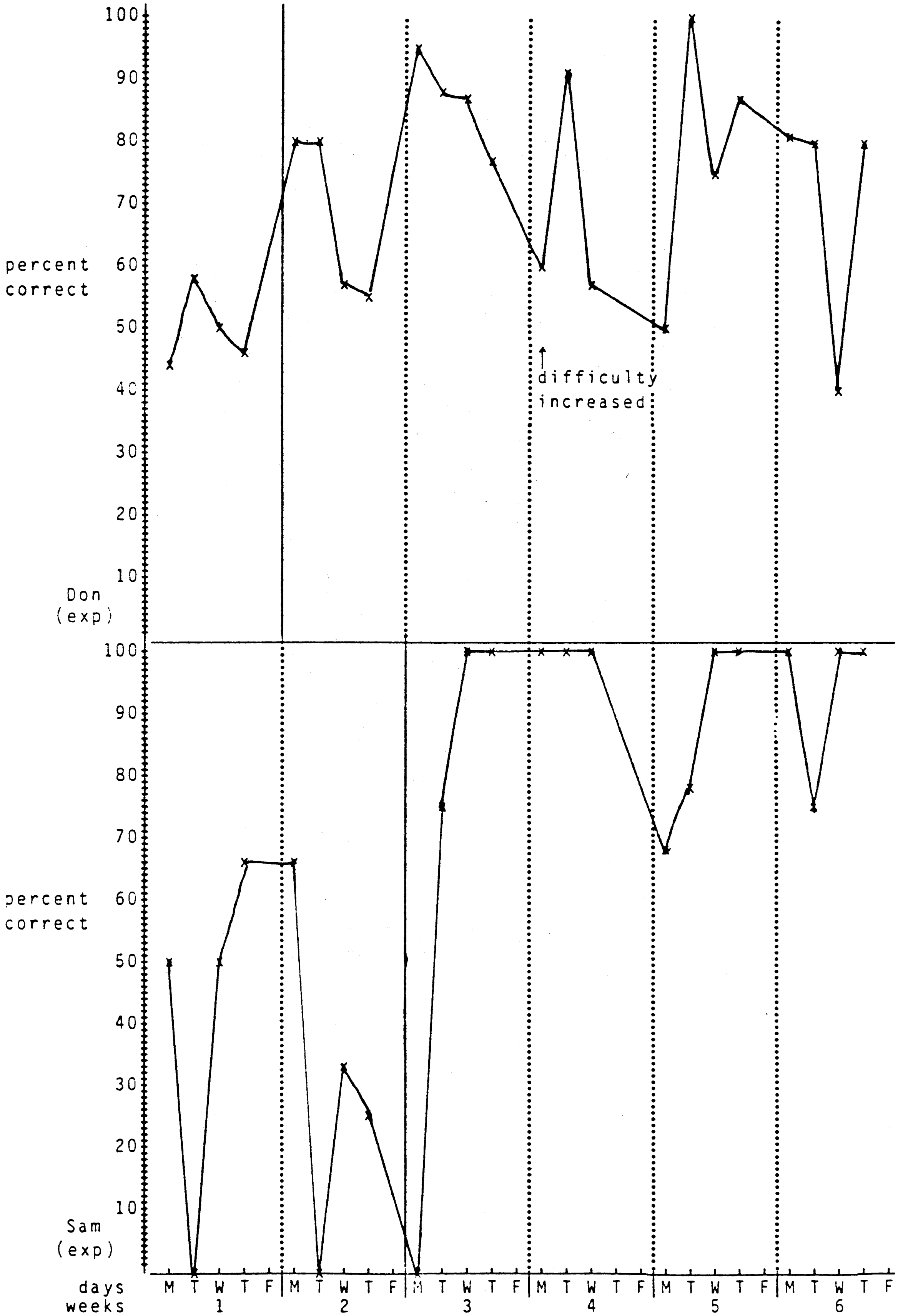


Figure 7.2. Percent correct during the lab quiz: Don and Sam.

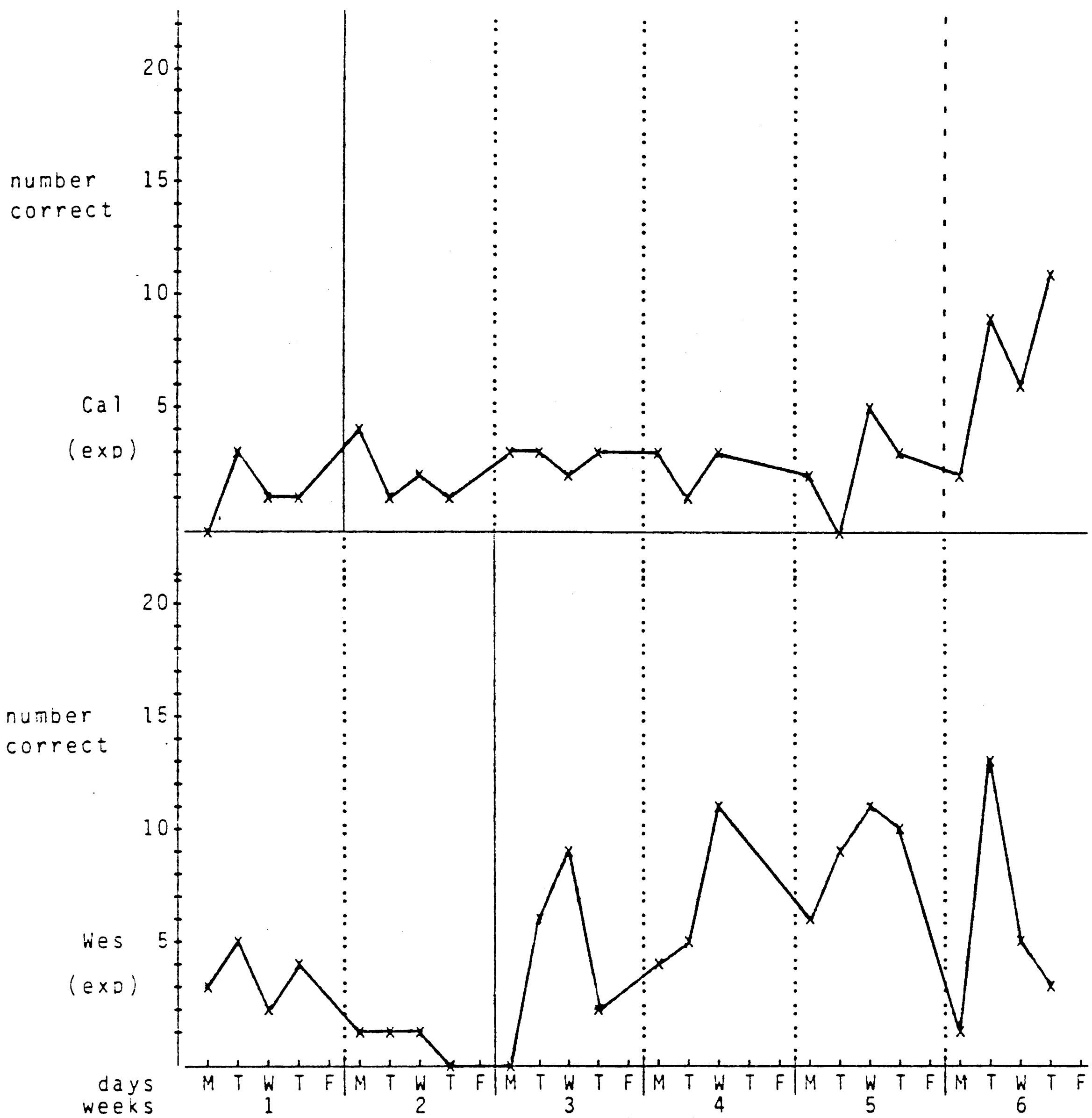


Figure 8.1. Number of correct responses during the lab quiz: Cal and Wes. The vertical dashed line indicates the point of modification in Cal's training.

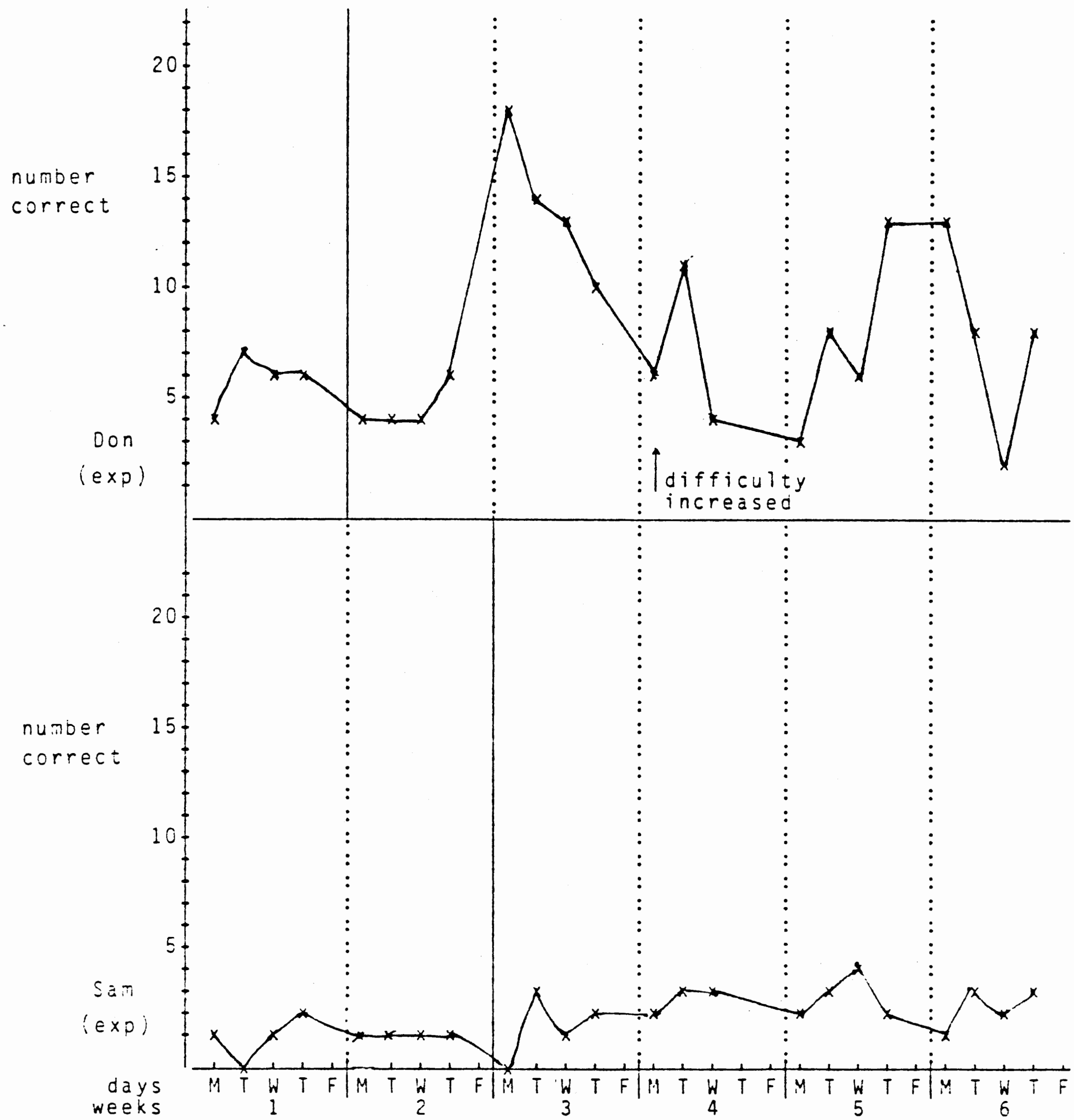


Figure 8.2. Number of correct responses during the lab quiz: Don and Sam. Because of the percent-correct scores, Don's difficulty level was increased on Monday of the fourth week.

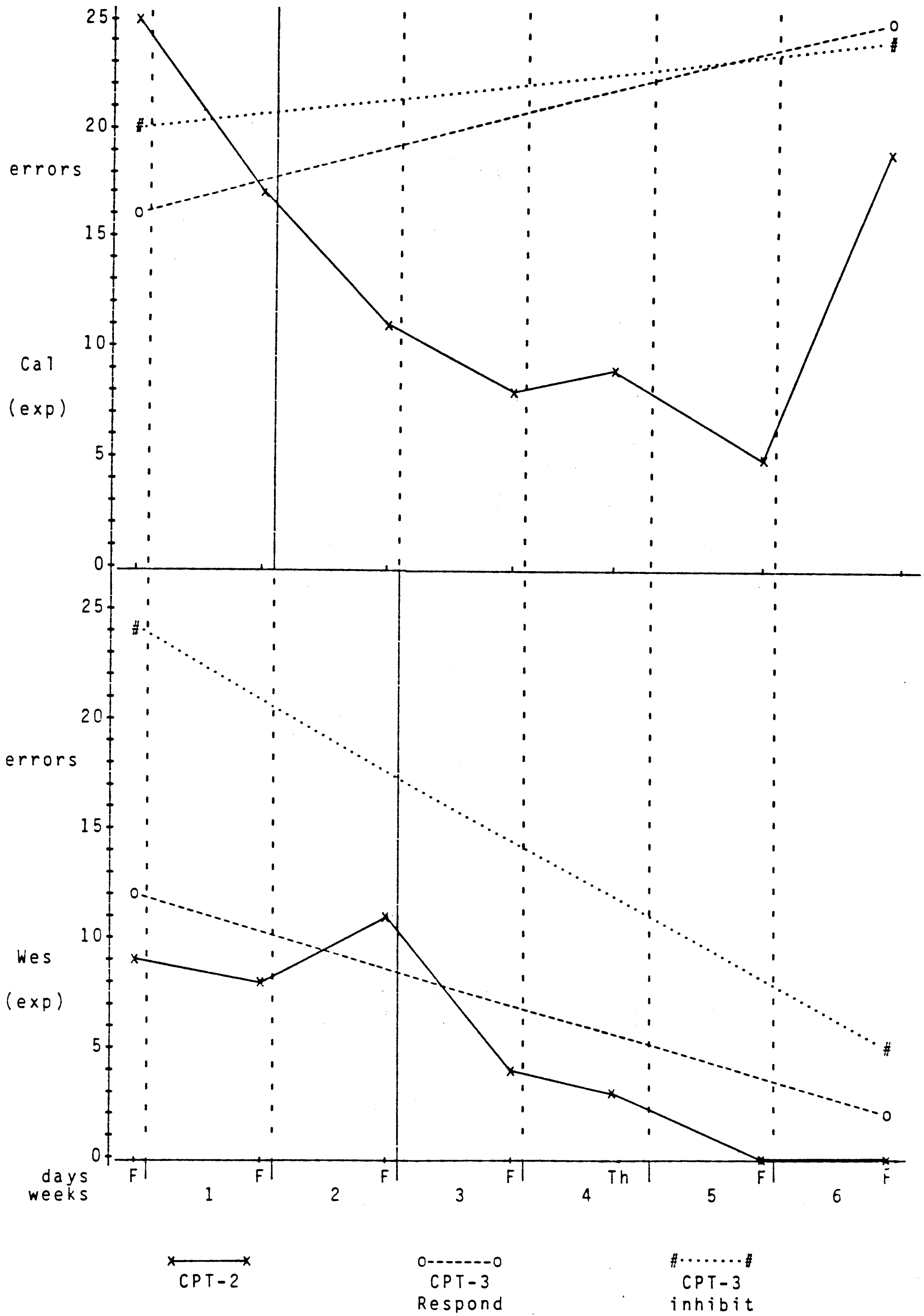


Figure 9.1. Numbers of commission errors on the Continuous Performance Task: Cal and Wes.

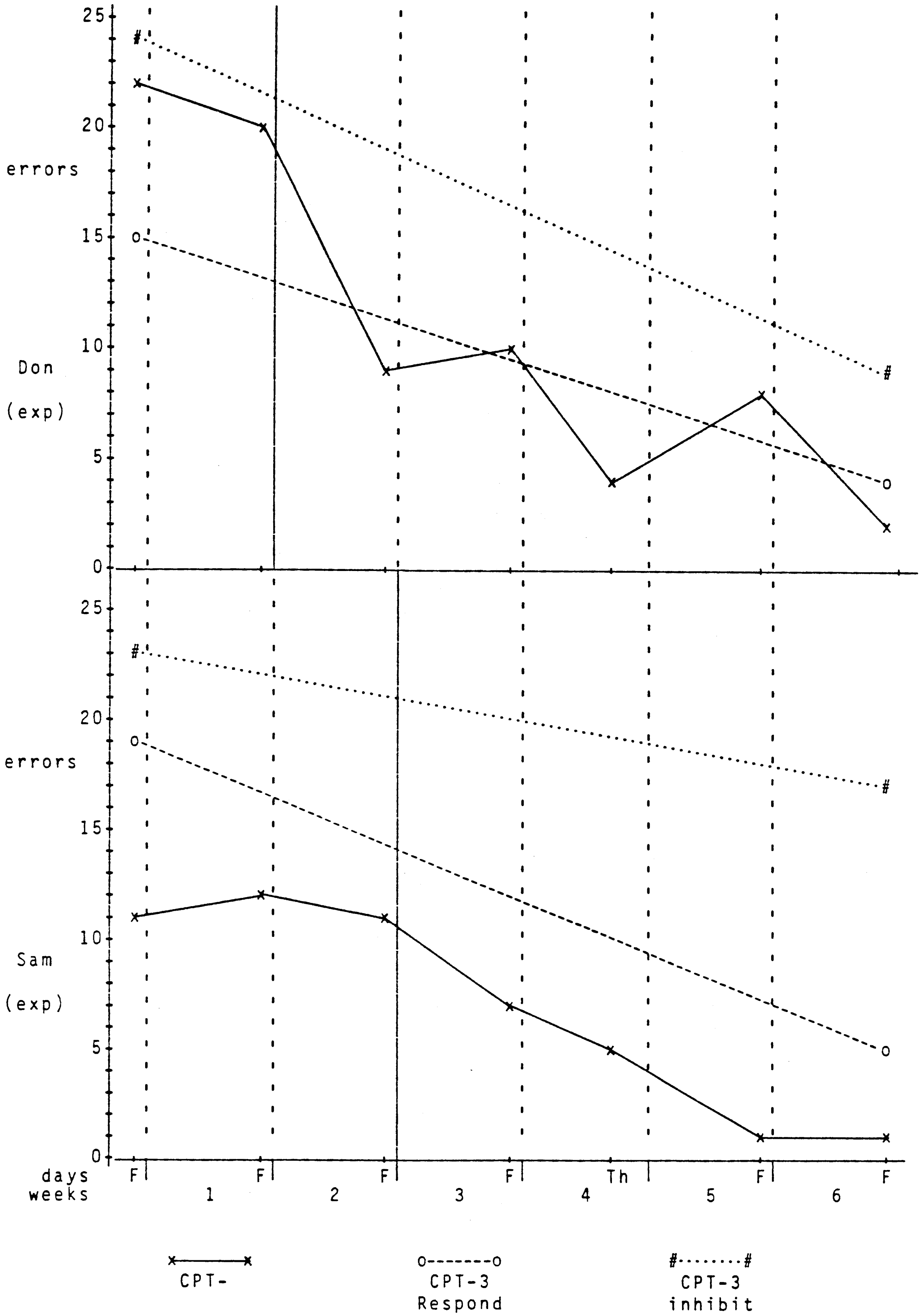


Figure 9.2. Numbers of commission errors on the Continuous Performance Task: Don and Sam.

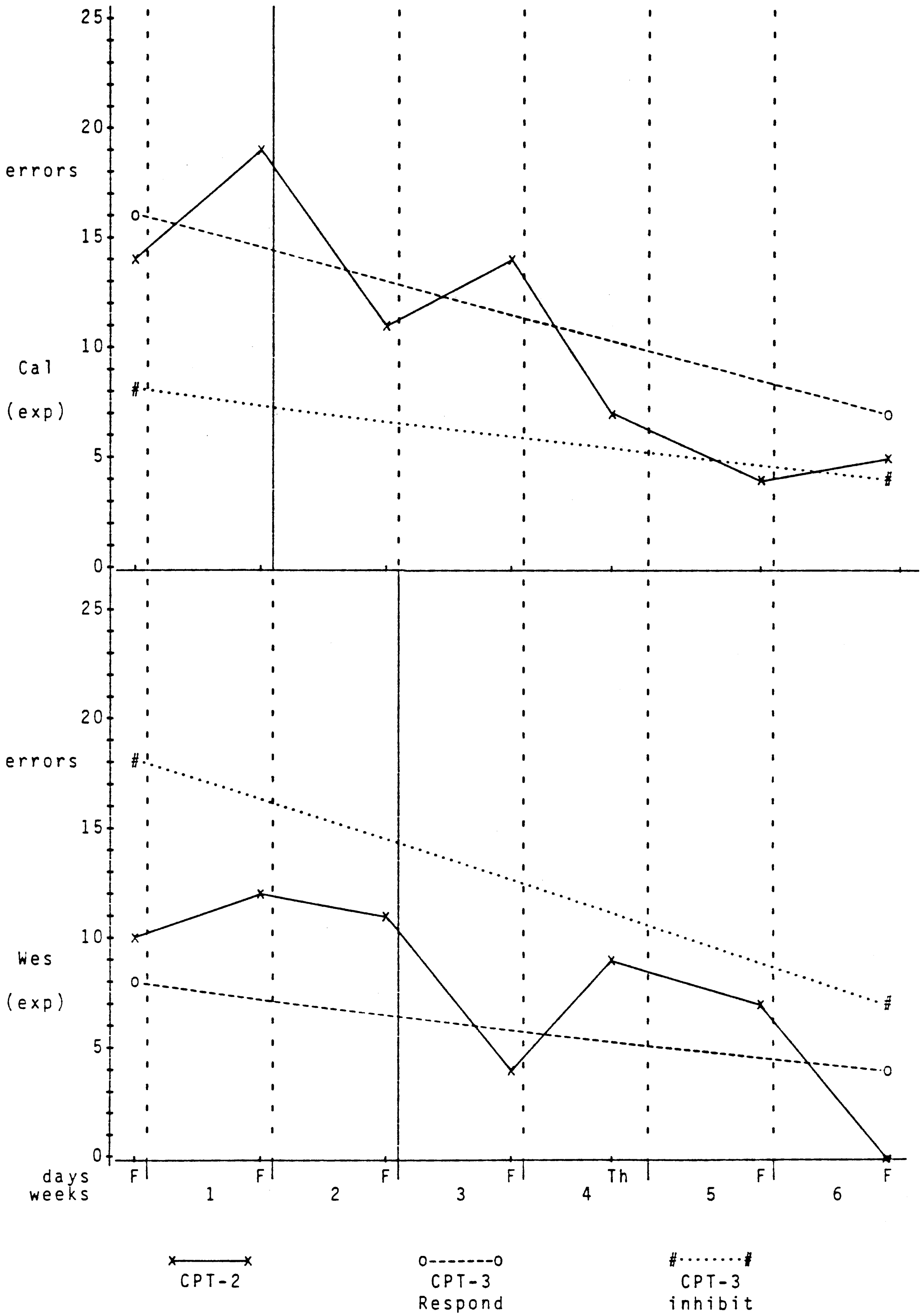


Figure 10.1. Numbers of omission errors on the Continuous Performance Task: Cal and Wes.

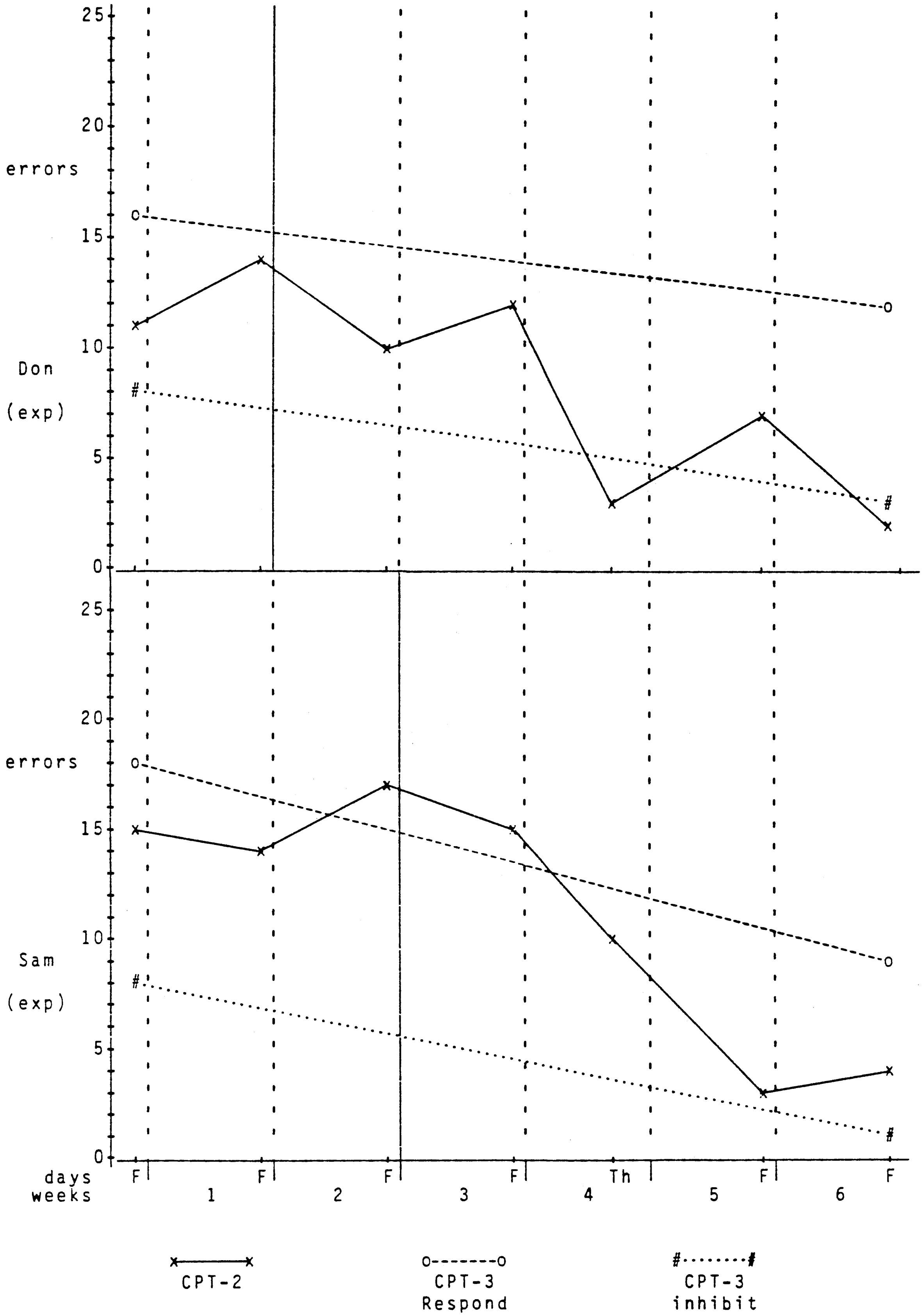


Figure 10.2. Numbers of omission errors on the Continuous Performance Task: Don and Sam.

APPENDIX E

CLASSROOM DATA

TABLE I

NAMES OF SUBJECTS IN EACH CLASSROOM

Measures Taken	Classroom			
	A	B	C	D
Observation and Quiz				
Experimental S	Cal	Don	Sam	Wes
Control S	Guy	Joy	Jay	Ric
Quiz Only				
Control S	Ted	Ray	Ean	May

TABLE II

PERCENT RELIABILITY: WEEKLY MEANS AND OVERALL MEANS FOR EACH SUBJECT FOR OCCURRENCE AND NON-OCCURRENCE OF ON-TASK BEHAVIOR (PRIMARY OBSERVER AND RELIABILITY CHECKER #1)

occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
1	87(2)	85(2)	92(2)	91(2)	85(3)	81(3)	84(3)	88(3)
2	84(3)	90(3)	88(3)	86(2)	90(2)	88(2)	92(2)	93(2)
3	95(2)	93(2)	94(2)	88(2)	90(3)	83(3)	86(3)	90(3)
4	81(2)	80(2)	92(2)	87(2)	100(2)	97(2)	83(2)	83(2)
5	88(3)	96(2)	86(3)	91(3)	80(1)	93(1)	93(2)	91(2)
6	94(2)	92(2)	92(2)	83(2)	92(2)	88(2)	86(2)	88(2)
mean:	**87.9**	**89.4**	**90.1**	**87.9**	**89.9**	**87.0**	**87.0**	**88.9**

non-occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
1	96(2)	96(2)	95(2)	91(2)	96(3)	96(3)	92(3)	93(3)
2	98(3)	97(3)	96(3)	94(2)	99(2)	99(2)	99(2)	95(2)
3	99(2)	98(2)	98(2)	96(2)	100(3)	97(3)	98(3)	94(3)
4	95(2)	97(2)	98(2)	97(2)	100(2)	99(2)	95(2)	91(2)
5	97(3)	99(3)	98(3)	98(3)	99(1)	96(1)	96(2)	96(2)
6	95(2)	97(2)	98(2)	96(2)	99(2)	97(2)	93(2)	92(2)
mean:	**96.8**	**97.3**	**97.1**	**95.5**	**98.7**	**97.3**	**95.7**	**93.5**

Figures in parentheses are the number of reliability checks upon which the weekly mean is based. Data for Cal and Guy in week five are not means, but are based on a single reliability check. Data in boldface are the means for each subject across the entire six-week time-span of the study.

TABLE III

WEEKLY MEANS OF PERCENT RELIABILITY FOR EACH SUBJECT: OCCURRENCE AND NON-OCCURRENCE OF ON-TASK BEHAVIOR (PRIMARY OBSERVER AND RELIABILITY CHECKER #2)

occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	**92**	**85**	-	-	**89**	**89**	89	89
02	91	91	**93**	**90**	88	88	100	95
03	100	95	88	80	100	90	**87**	**87**
04	81	83	83	80	**86**	**83**	-	-
05	83	-	**100**	**92**	-	-	**85**	**87**
06	**88**	**86**	-	-	**88**	**86**	-	-

non-occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	**98**	**96**	-	-	**96**	**98**	96	91
02	98	94	**97**	**95**	99	98	100	95
03	100	98	99	94	100	98	**96**	**92**
04	96	97	98	93	**99**	**95**	-	-
05	93	-	**100**	**92**	-	-	**92**	**95**
06	**91**	**94**	-	-	**98**	**97**	-	-

Boldfaced figures are means based on measurements from two days. All other figures are based on measurements from a single day.

TABLE IV

WEEKLY MEANS OF PERCENT RELIABILITY FOR EACH SUBJECT: OCCURRENCE AND NON-OCCURRENCE OF ON-TASK BEHAVIOR (RELIABILITY CHECKERS #1 AND #2)

occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	**85**	**82**	-	-	**85**	**83**	95	89
02	83	86	**89**	**95**	88	88	100	92
03	100	95	88	80	100	90	**84**	**85**
04	88	92	83	93	**86**	**80**	-	-
05	92	-	**93**	**93**	-	-	**86**	**88**
06	**90**	**90**	-	-	**88**	**92**	-	-

non-occurrence

wk	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	**95**	**95**	-	-	**95**	**96**	98	92
02	97	90	**96**	**98**	99	98	100	93
03	100	98	99	94	100	98	**95**	**91**
04	97	99	98	98	**99**	**95**	-	-
05	97	-	99	92	-	-	**92**	**94**
06	**88**	**95**	-	-	**98**	**99**	-	-

Boldfaced figures are means based on measurements from two days. All other figures are based on measurements from a single day.

TABLE VI

PERCENT ON TASK: DAILY PERCENT OF INTERVALS ON TASK WITH WEEKLY SUMMARIES SHOWING MEANS AND STANDARD DEVIATIONS

wk	date	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	6/09	22	10	50	33	28	17	33	30
	6/10	22	15	50	49	21	29	29	31
	6/11	34	29	31	32	18	19	31	32
	6/12	18	30	31	41	18	18	52	38
	6/13	36	30	30	35	14	14	27	47
	mean	**26.5**	**22.8**	**38.5**	**38.1**	**19.7**	**19.1**	**34.6**	**35.6**
	s.d.	7.2	8.5	9.4	6.1	4.9	5.1	9.2	6.1
02	6/16	6	2	29	absent	15	22	15	25
	6/17	22	20	8	22	5	8	4	46
	6/18	6	15	22	31	20	11	42	51
	6/19	12	16	19	31	9	10	14	36
	6/20	14	39	24	24	16	11	33	40
	mean	**12.3**	**18.5**	**20.2**	**27.1**	**13.0**	**12.6**	**21.7**	**39.8**
	s.d.	6.0	11.7	7.1	4.1	5.4	5.1	14.1	9.0
03	6/23	11	38	20	22	1	15	11	35
	6/24	6	22	18	22	0	11	25	32
	6/25	12	35	13	20	0	13	22	33
	6/26	14	22	9	24	2	11	10	21
	6/27	14	5	12	26	5	12	24	38
	mean	**11.5**	**24.6**	**14.2**	**22.9**	**1.8**	**12.7**	**18.4**	**32.1**
	s.d.	3.0	11.4	4.1	2.1	1.9	1.4	6.4	5.8
04	6/30	20	6	8	21	17	7	19	38
	7/01	16	42	3	18	8	24	7	23
	7/02	16	12	14	12	15	absent	17	10
	7/03	34	38	19	19	0	9	31	47
	mean	**21.6**	**24.9**	**11.2**	**17.2**	**10.0**	**13.4**	**18.5**	**29.4**
	s.d.	7.2	15.7	6.3	3.4	6.7	7.8	8.8	13.9
05	7/07	24	absent	12	18	6	12	28	62
	7/08	38	14	9	24	5	34	35	42
	7/09	19	14	8	15	2	25	31	40
	7/10	56	45	18	absent	-	-	32	25
	7/11	0	2	10	65	11	30	38	31
	mean	**27.2**	**18.7**	**11.3**	**30.2**	**6.0**	**25.3**	**32.7**	**40.2**
	s.d.	18.8	15.8	3.5	20.3	3.2	8.3	3.2	12.7
06	7/14	24	23	6	16	1	11	36	30
	7/15	66	38	1	15	1	14	36	30
	7/16	26	48	12	25	15	16	22	49
	7/17	18	14	24	21	2	10	56	42
	mean	**33.5**	**30.7**	**10.8**	**9.4**	**5.0**	**12.8**	**37.6**	**37.8**
	s.d.	19.1	13.2	8.3	3.7	5.8	2.4	12.1	8.1

TABLE VII

PERCENT ON TASK: WEEKLY SUMMARIES WITH SUMS OF SQUARES, NUMBERS OF DAYS OF MEASUREMENT, MEANS, AND STANDARD DEVIATIONS

week	statistic	Wes	Ric	Sam	Jay	Cal	Guy	Don	Joy
01	sum sqs	3772	2952	7853	7457	2056	1951	6414	6517
	n	5	5	5	5	5	5	5	5
	mean	26.5	22.8	38.5	38.1	19.7	19.1	34.6	35.6
	s.d.	7.2	8.5	9.4	6.1	4.9	5.1	9.2	6.1
02	sum sqs	934	2397	2305	3014	991	925	3345	8313
	n	5	5	5	4	5	5	5	5
	mean	12.3	18.5	20.2	27.1	13.0	12.6	21.7	39.8
	s.d.	6.0	11.7	7.1	4.1	5.4	5.1	14.1	9.0
03	sum sqs	709	3672	1089	2653	33	812	1902	5313
	n	5	5	5	5	5	5	5	5
	mean	11.5	24.6	14.2	22.9	1.8	12.7	18.4	32.1
	s.d.	3.0	11.4	4.1	2.1	1.9	1.4	6.4	5.8
04	sum sqs	2067	3468	659	1222	578	719	1675	4228
	n	4	4	4	4	4	3	4	4
	mean	21.6	24.9	11.2	17.2	10.0	13.4	18.5	29.4
	s.d.	7.2	15.7	6.3	3.4	6.7	7.8	8.8	13.9
05	sum sqs	5486	2403	701	5310	186	2825	5403	8891
	n	5	4	5	4	4	4	5	5
	mean	27.2	18.7	11.3	30.2	6.0	25.3	32.7	40.2
	s.d.	18.8	15.8	3.5	20.3	3.2	8.3	3.2	12.7
06	sum sqs	5943	4473	743	1563	235	680	6239	5976
	n	4	4	4	4	4	4	4	4
	mean	33.5	30.7	10.8	19.4	5.0	12.8	37.6	37.8
	s.d.	19.1	13.2	8.3	3.7	5.8	2.4	12.1	8.1

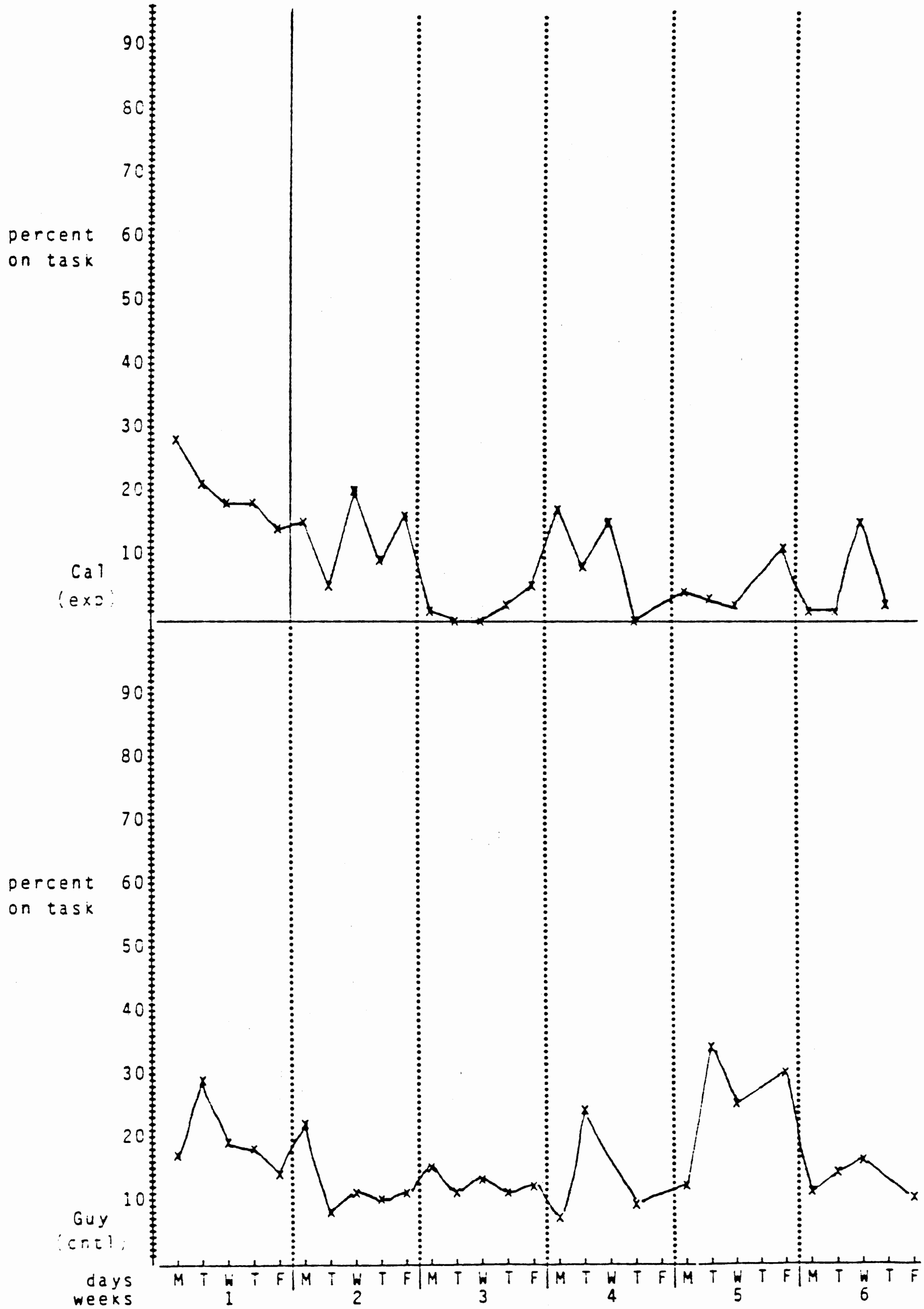


Figure 11.1. On-task behavior in the classroom: Cal and Guy. The ordinate indicates the percent of intervals subjects were on task. The solid vertical line shows the initiation of training.

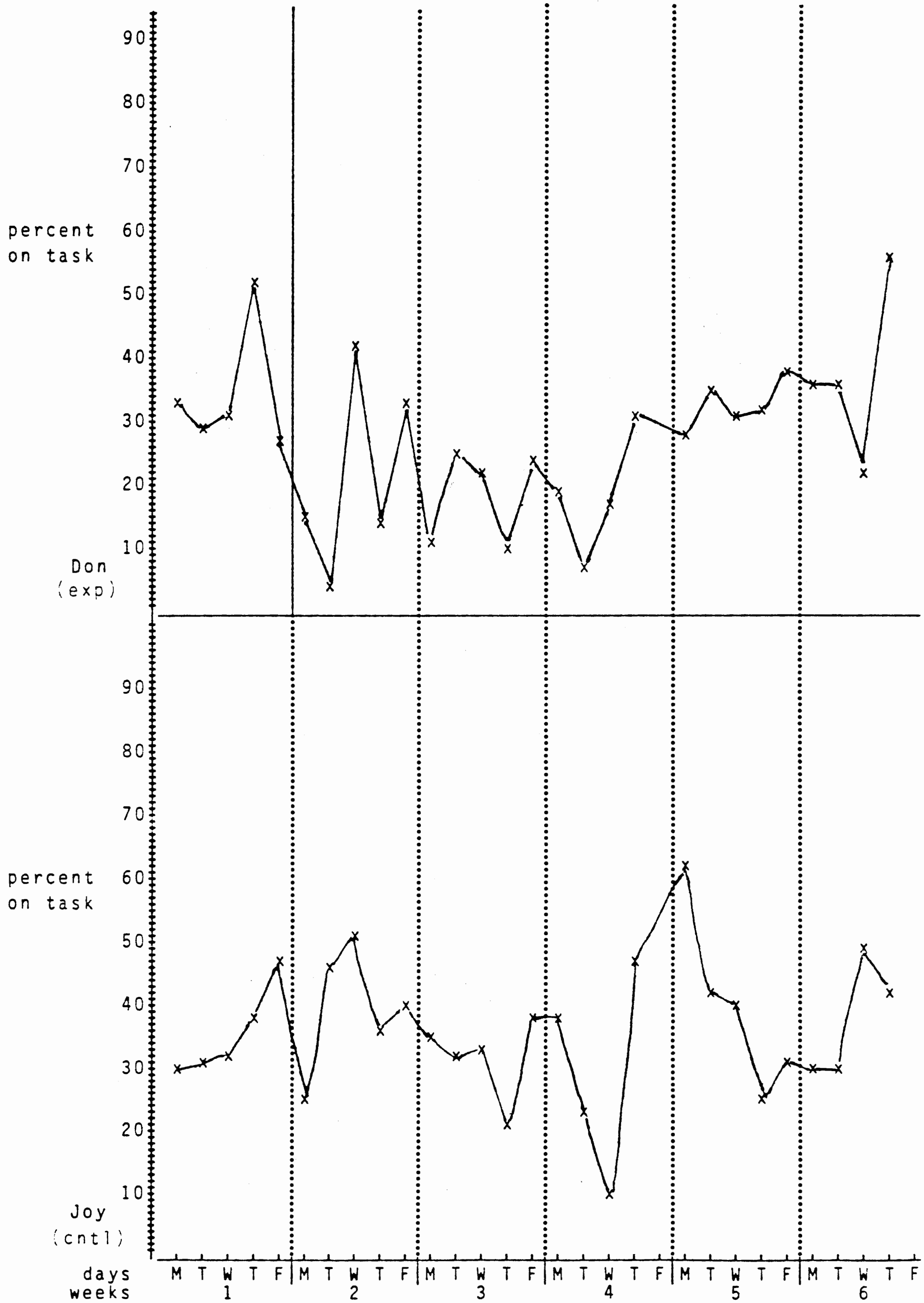


Figure 11.2. On-task behavior in the classroom: Don and Joy. The ordinate indicates the percent of intervals subjects were on task. The solid vertical line shows the initiation of training.

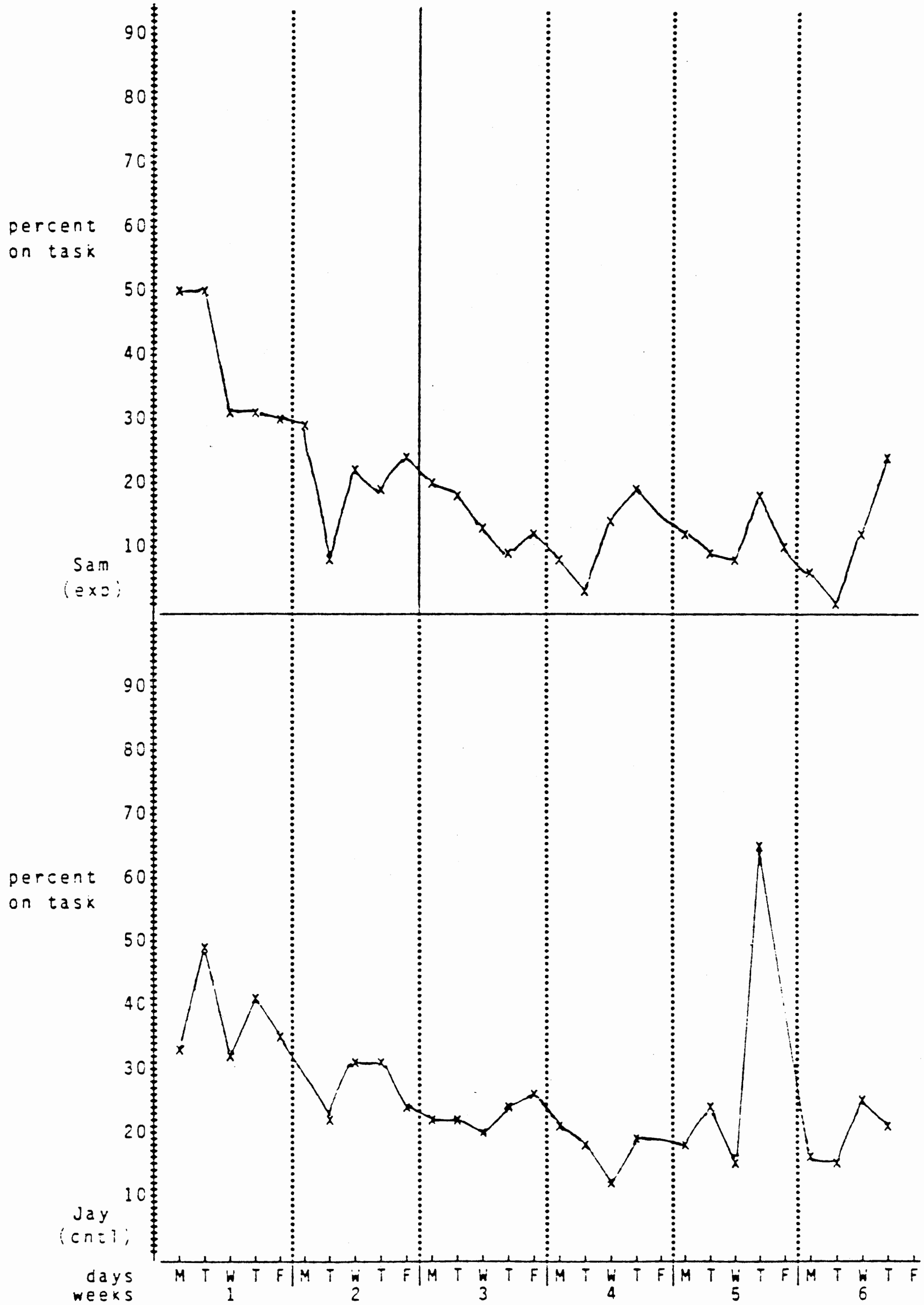


Figure 11.3. On-task behavior in the classroom: Sam and Jay. The ordinate indicates the percent of intervals subjects were on task. The solid vertical line shows the initiation of training.

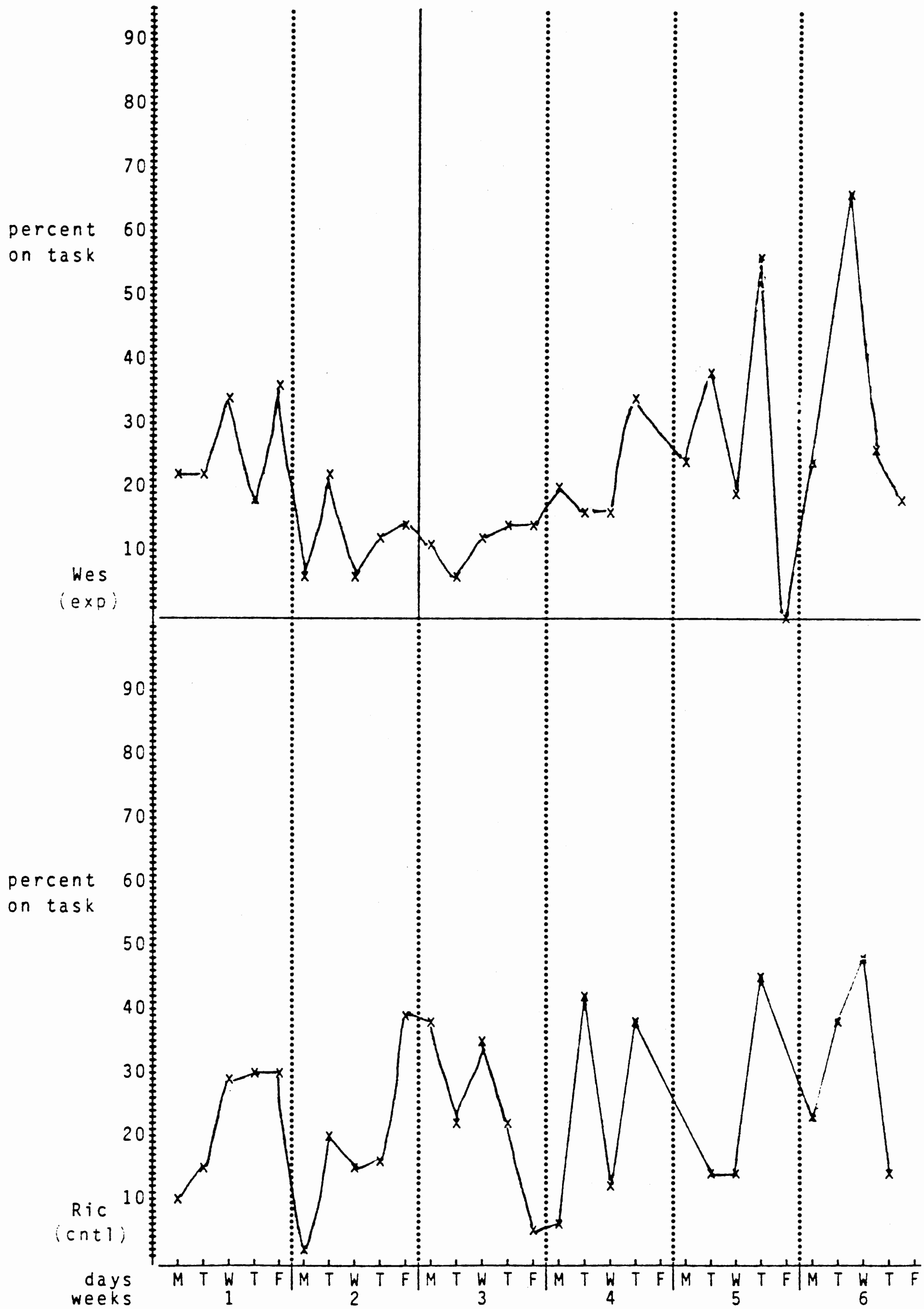


Figure 11.4. On-task behavior in the classroom: Wes and Ric. The ordinate indicates the percent of intervals subjects were on task. The solid vertical line shows the initiation of training.

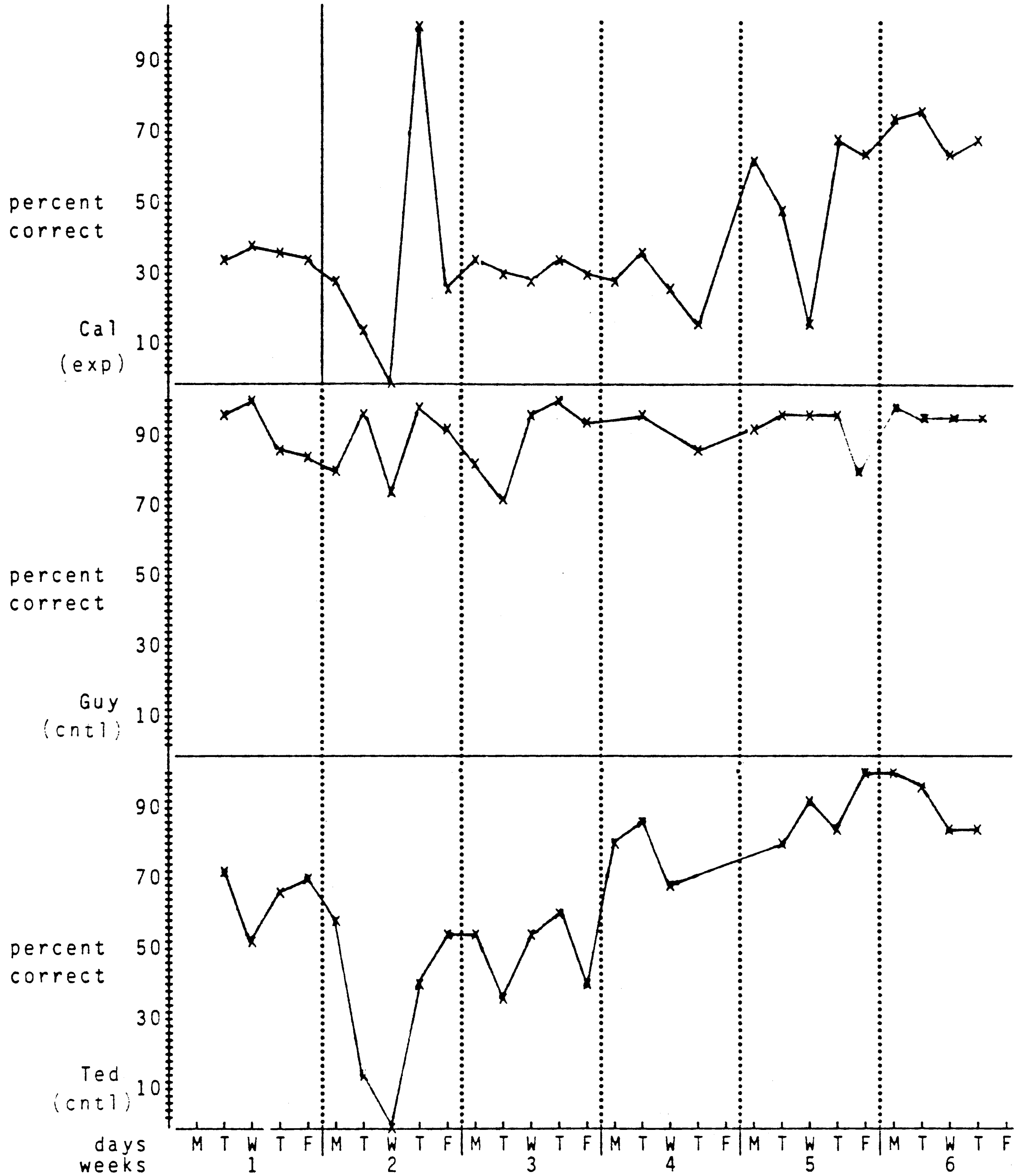


Figure 12.1. Percent correct on the classroom math quiz: Cal, Guy, and Ted.

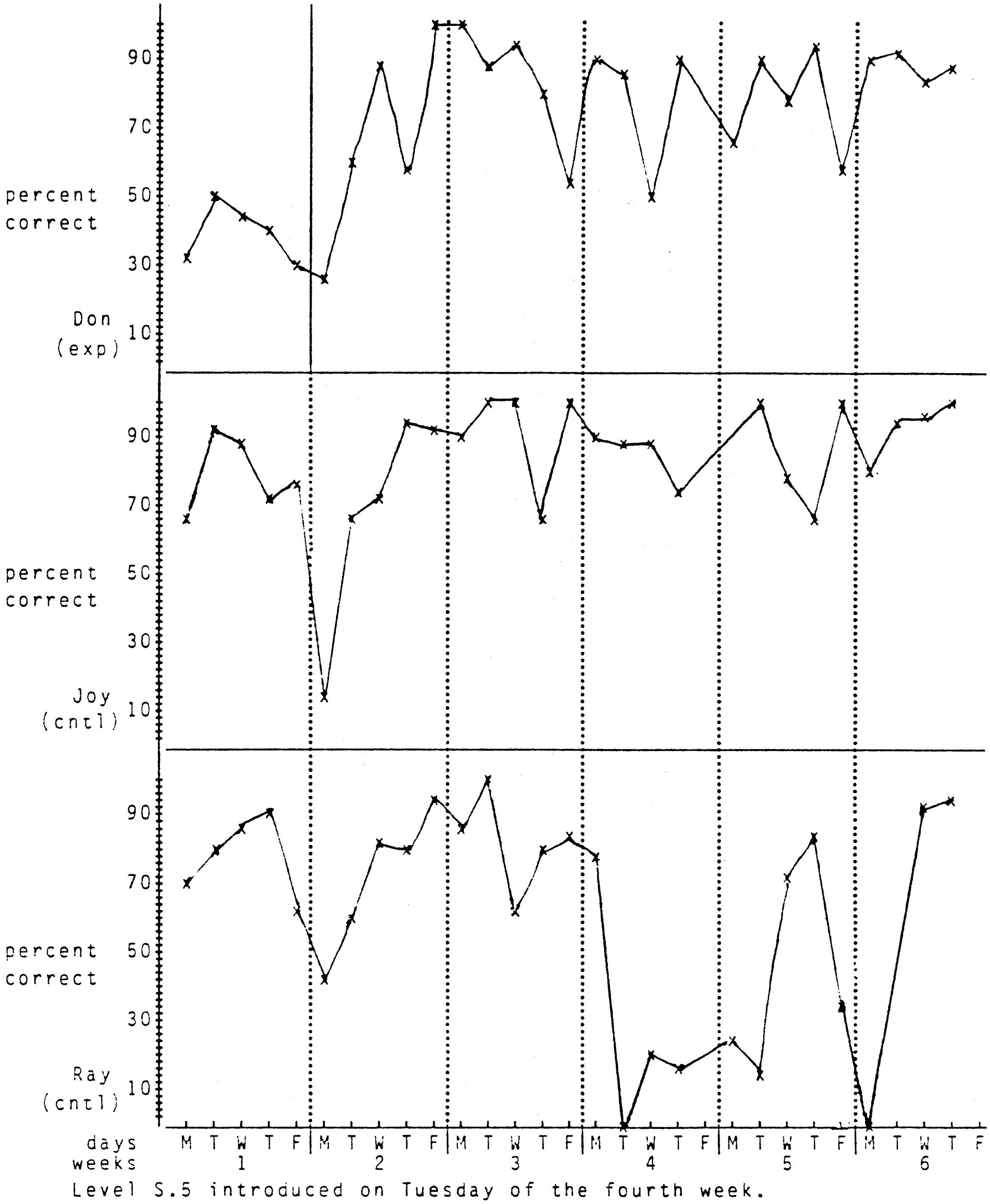


Figure 12.2. Percent correct on the classroom math quiz: Don, Joy, and Ray. The level of difficulty was increased on Tuesday of the fourth week.

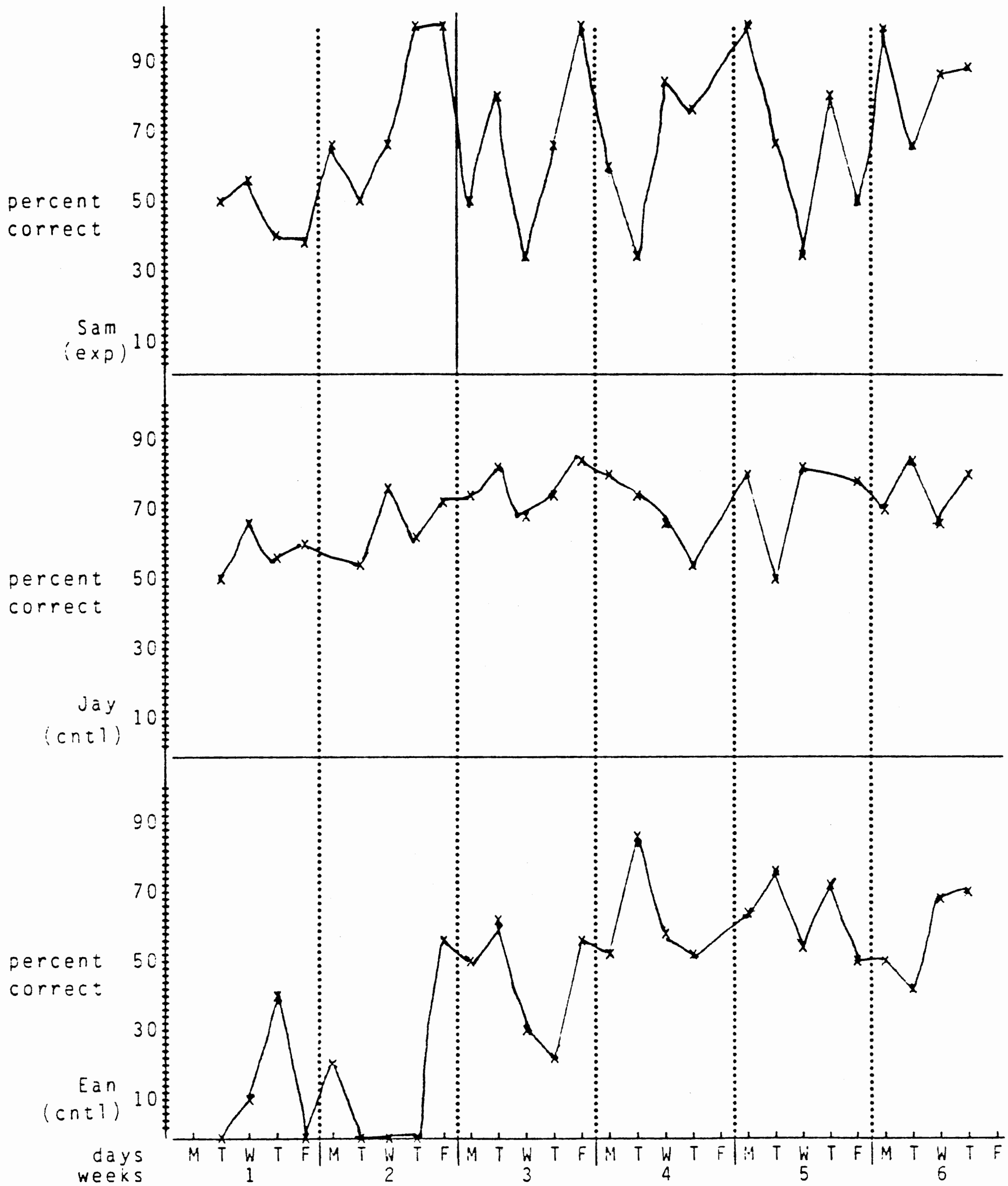


Figure 12.3. Percent correct on the classroom math quiz: Sam, Jay, and Ean.

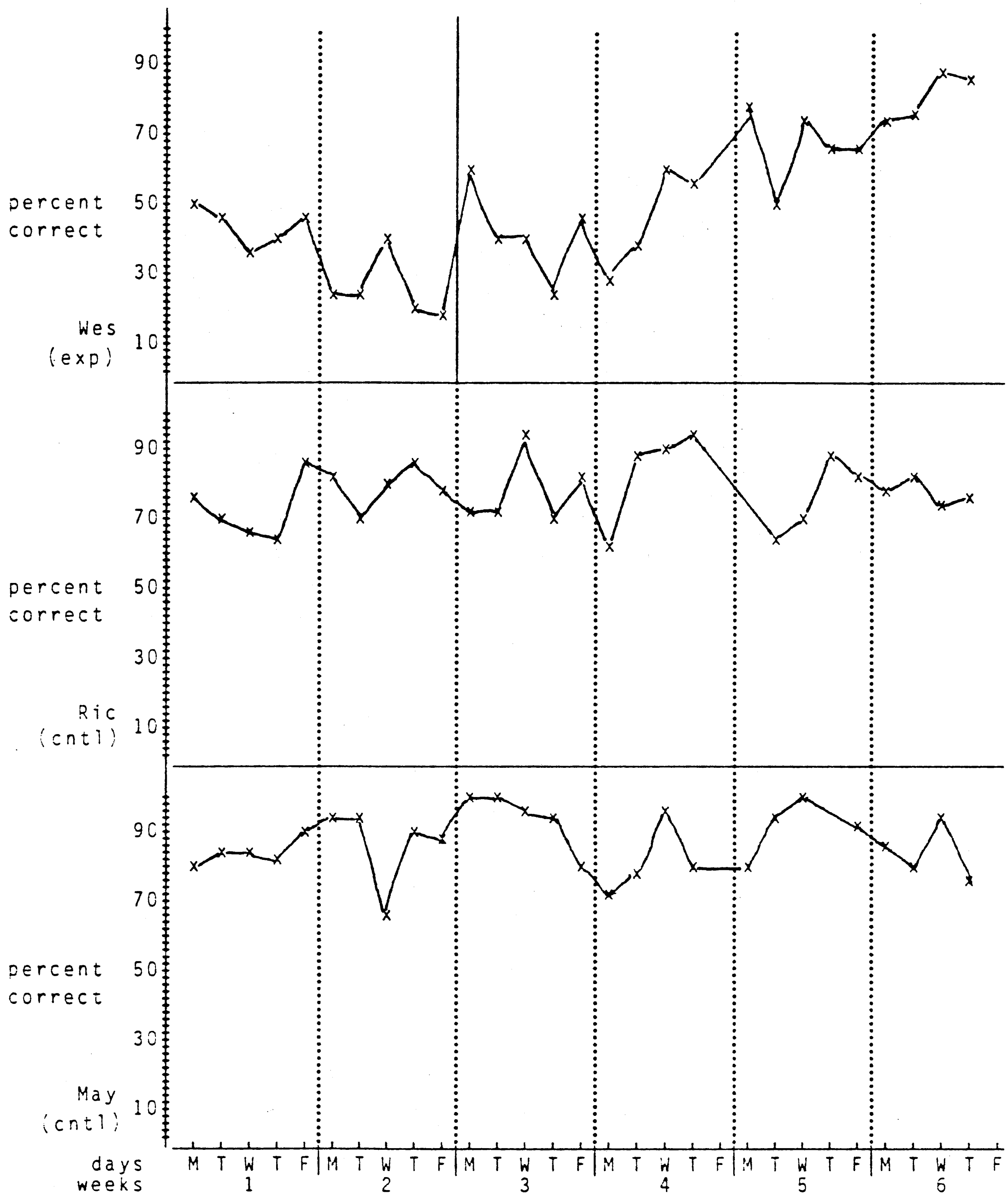


Figure 12.4. Percent correct on the classroom math quiz: Wes, Ric, and May. An extra 30 seconds was given on Friday of the first week due to an error in timing.

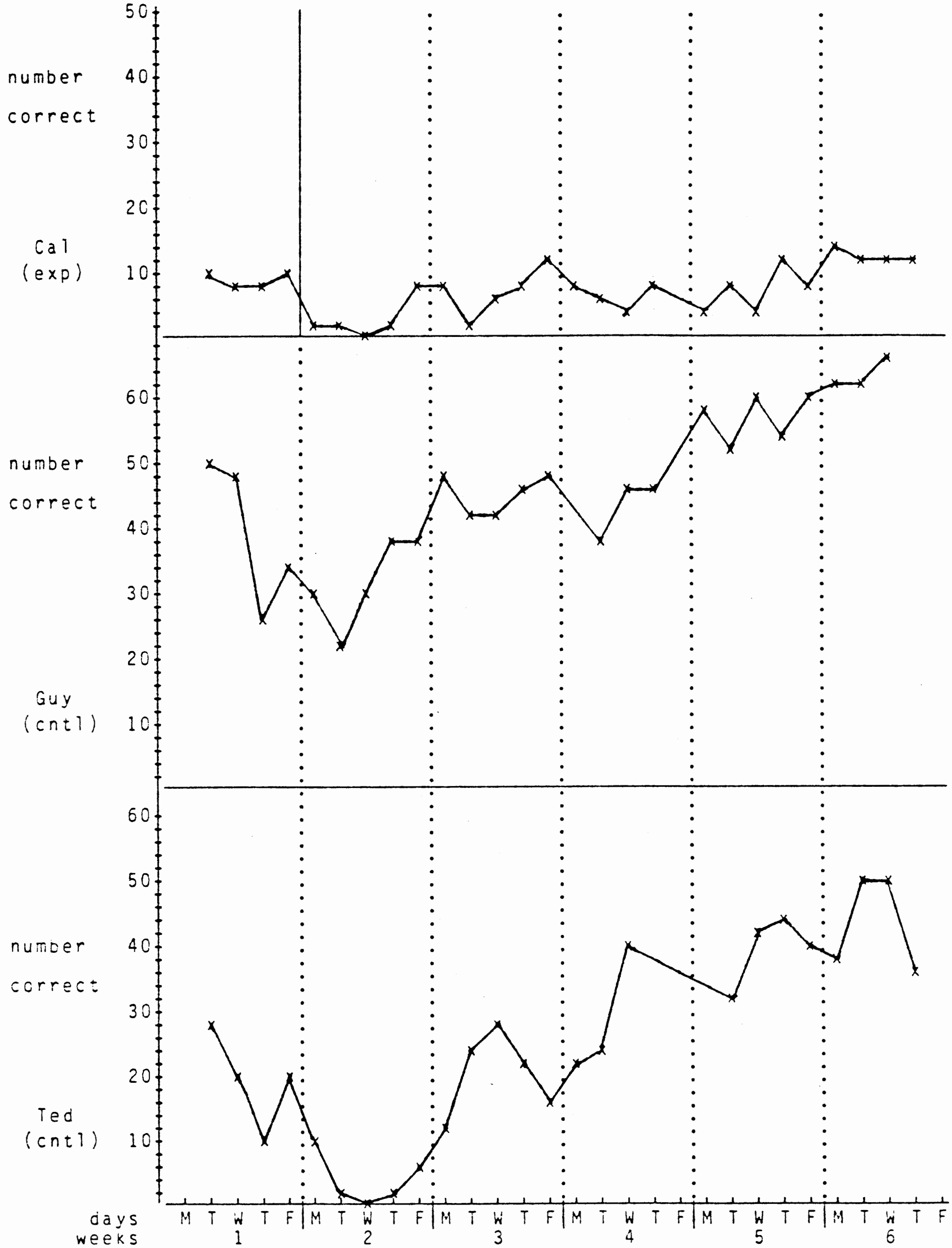


Figure 13.1. Number of correct responses on the classroom math quiz: Cal, Guy, and Ted. The solid vertical line indicates the initiation of training.

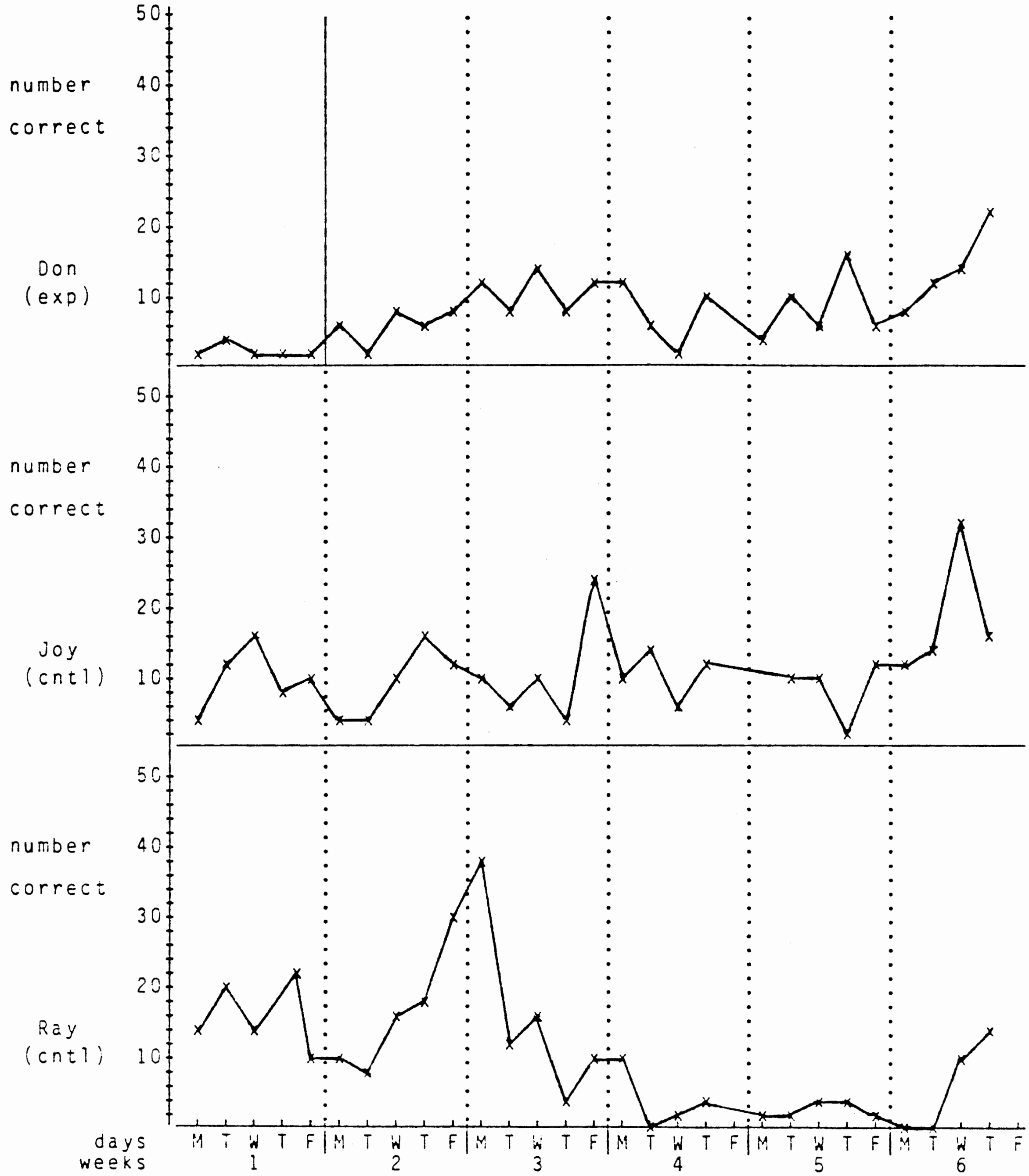


Figure 13.2. Number of correct responses on the classroom math quiz: Don, Joy, and Ray. The level of difficulty was increased on Tuesday of the fourth week. The solid vertical line indicates the initiation of training.

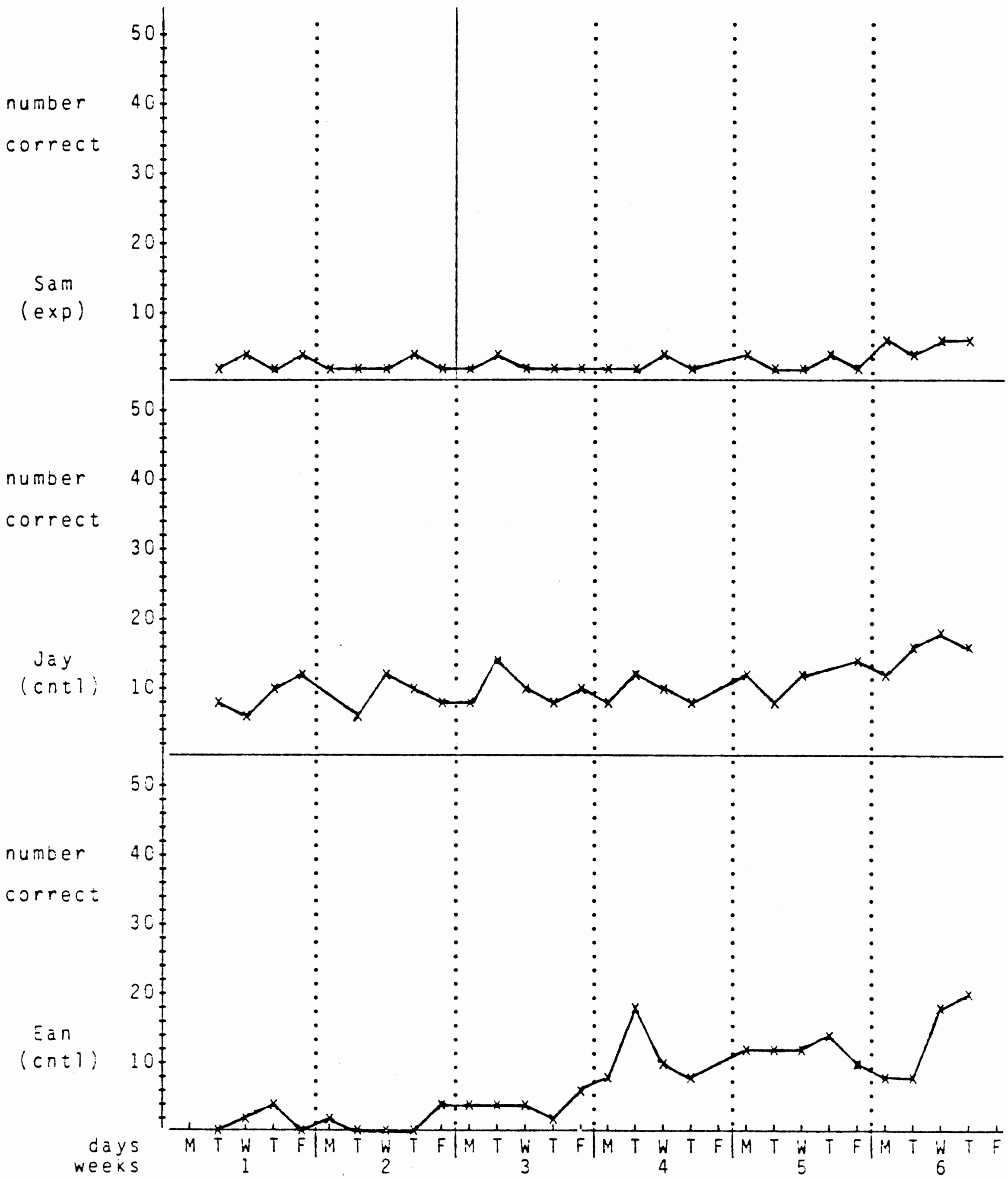


Figure 13.3. Number of correct responses on the classroom math quiz: Sam, Jay, and Ean. The solid vertical line indicates the initiation of training.

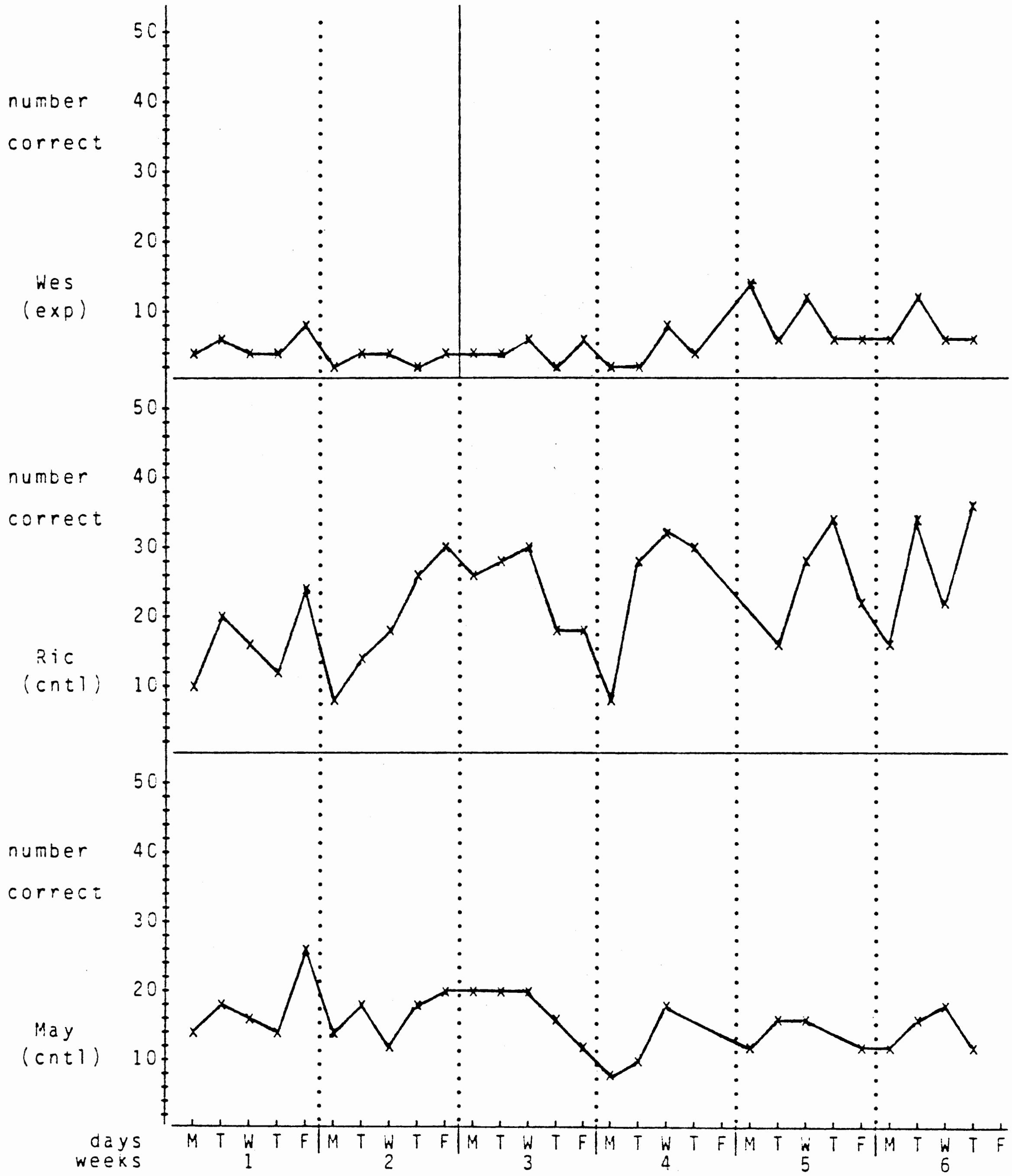


Figure 13.4. Number of correct responses on the classroom math quiz: Wes, Ric, and May. An extra 30 seconds was given on Friday of the first week due to an error in timing. The solid vertical line indicates the initiation of training.

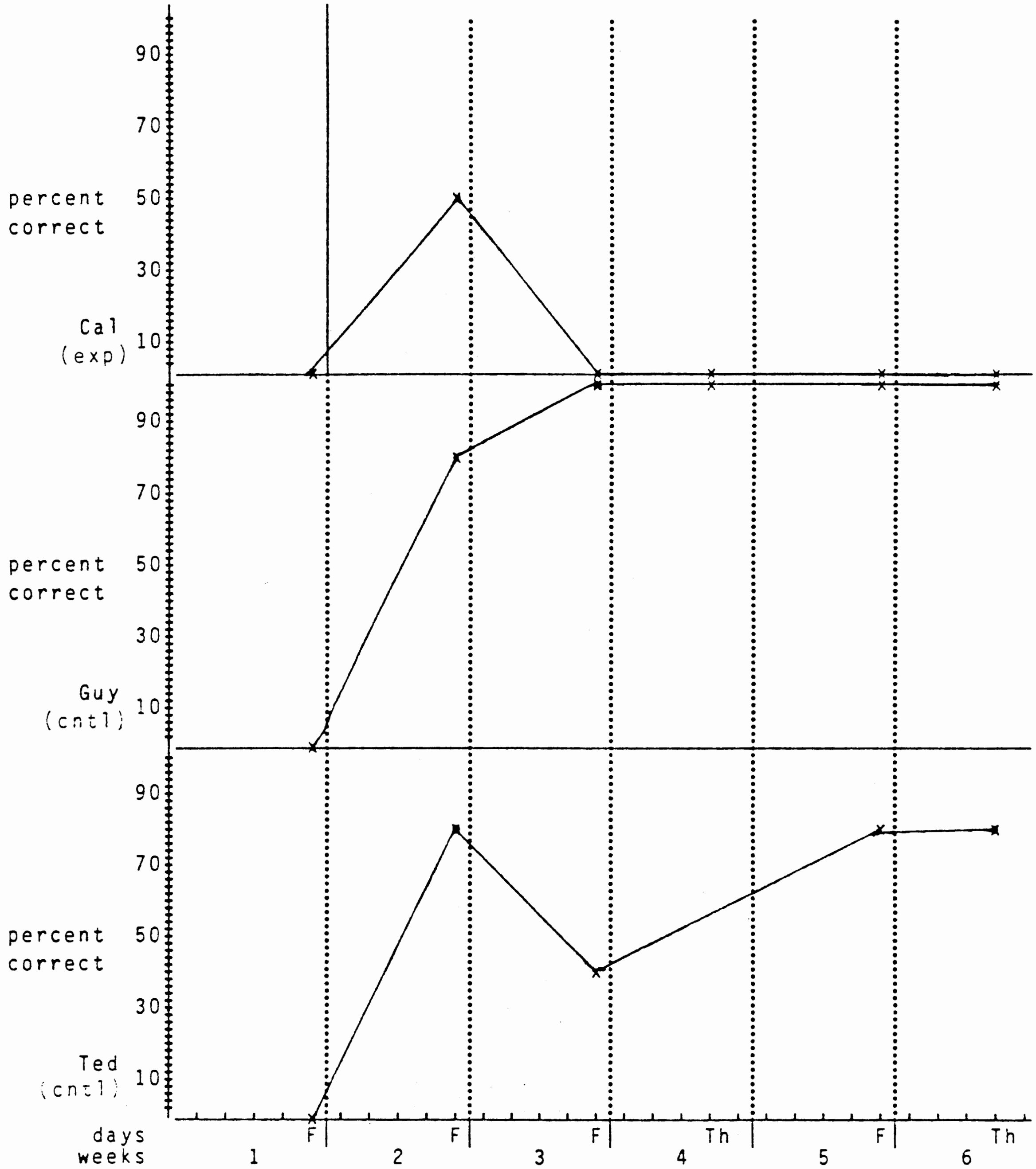


Figure 14.1. Percent correct on the classroom word problems: Cal, Guy, and Ted.

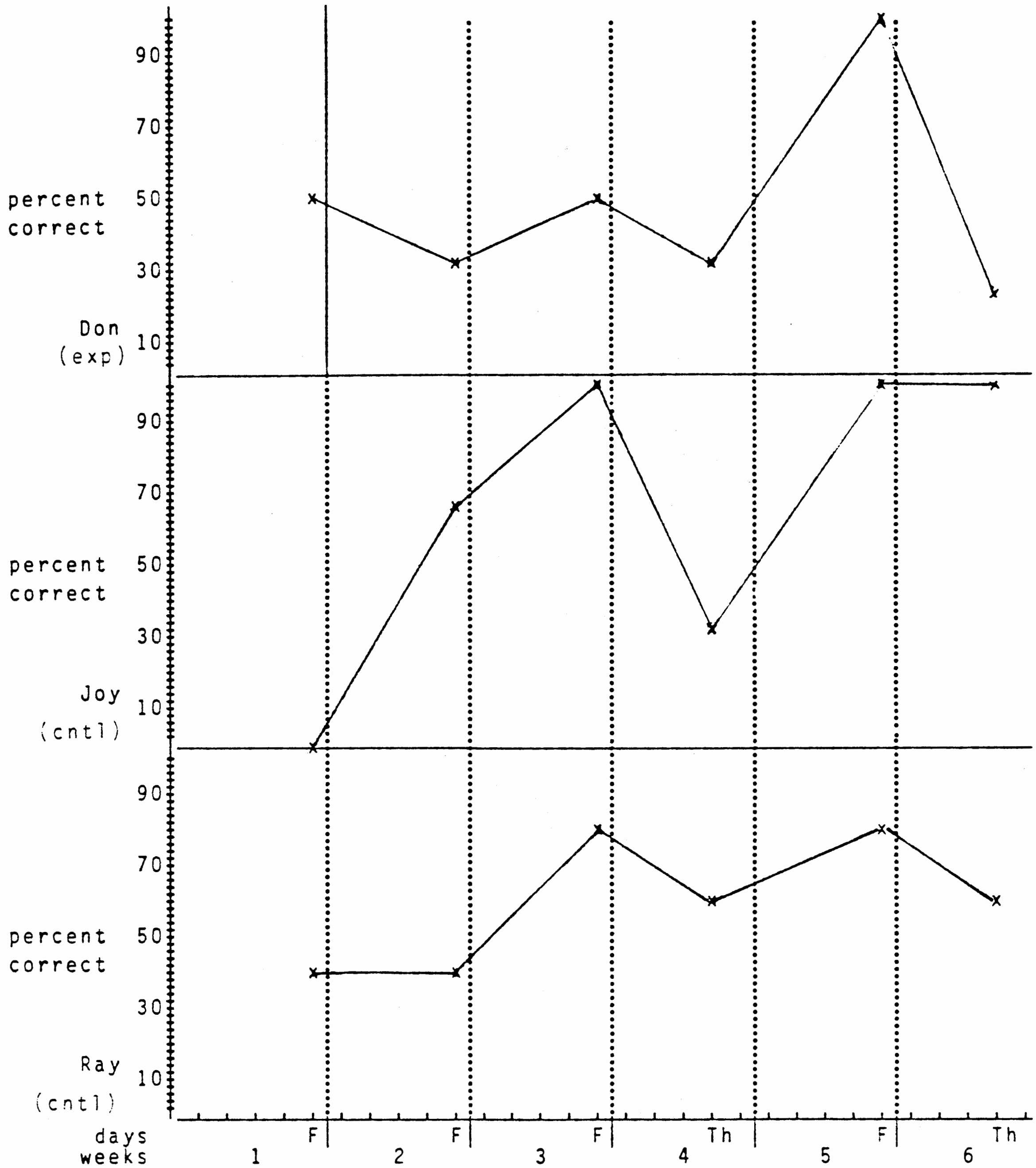


Figure 14.2. Percent correct on the classroom word problems: Don, Joy, and Ray. The difficulty level was increased the fourth week.

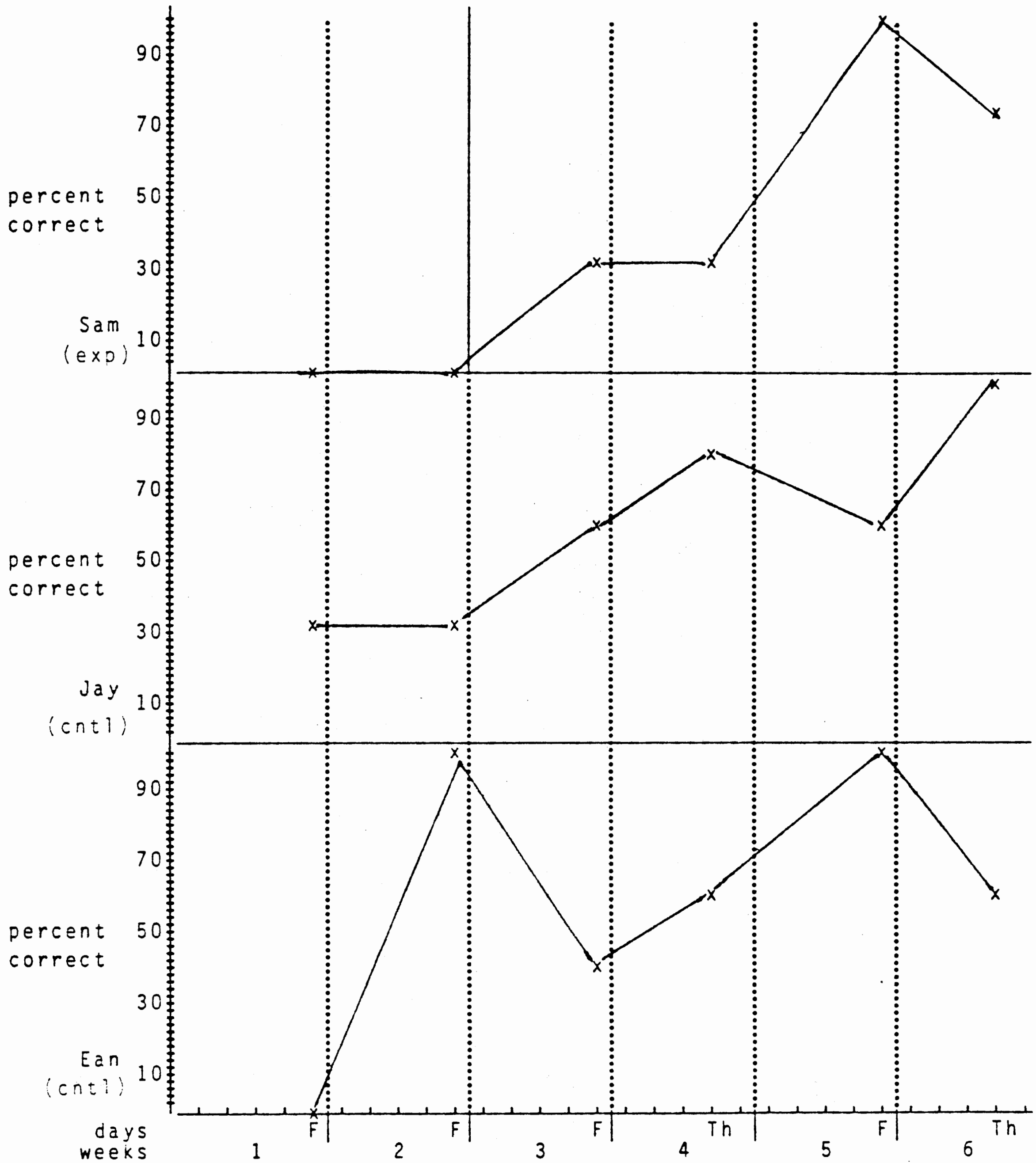


Figure 14.3. Percent correct on the classroom word problems: Sam, Jay, and Ean.

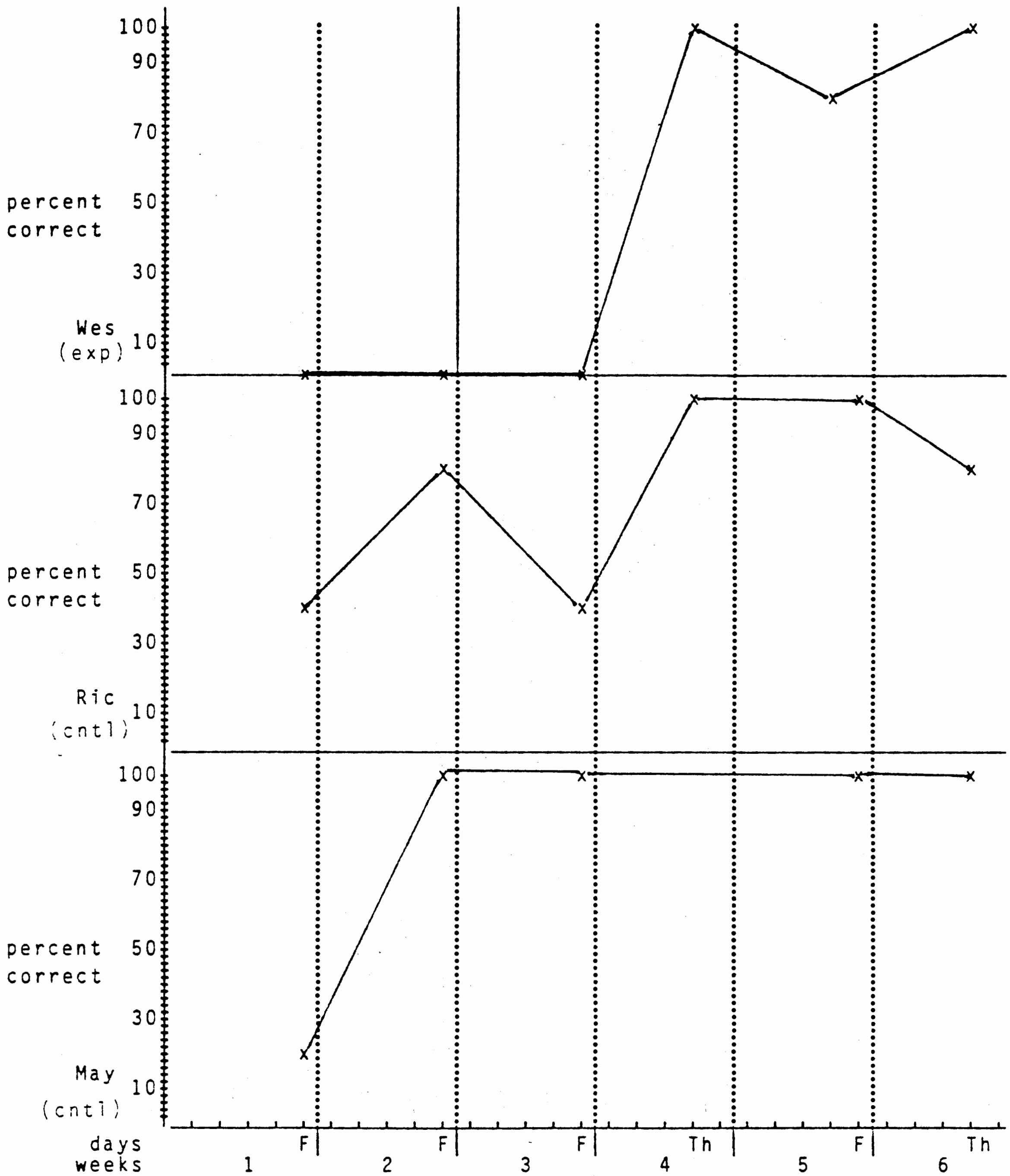


Figure 14.4. Percent correct on the classroom word problems: Wes, Ric, and May.

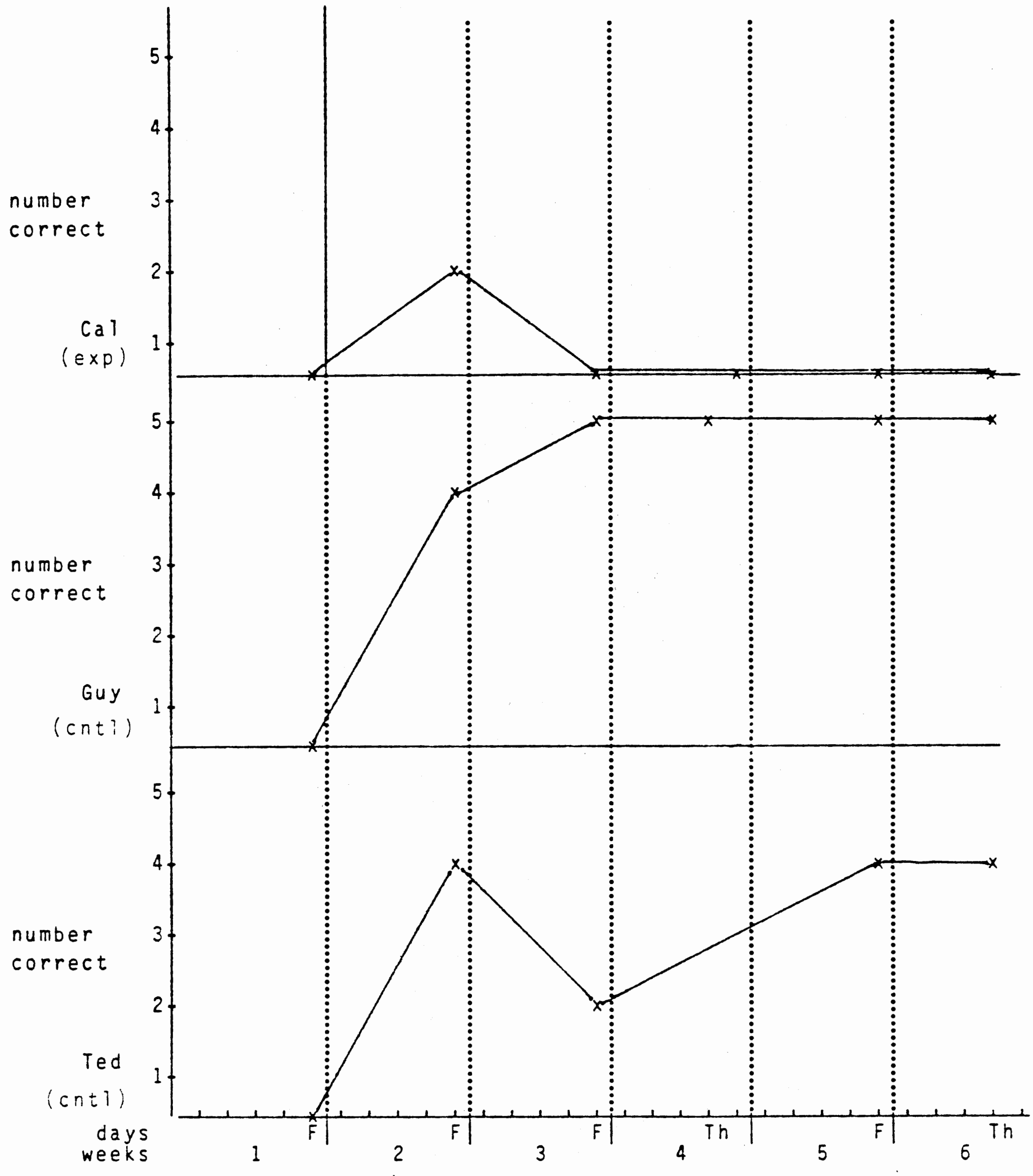


Figure 15.1. Number of correct responses on the classroom word problems: Cal, Guy, and Ted.

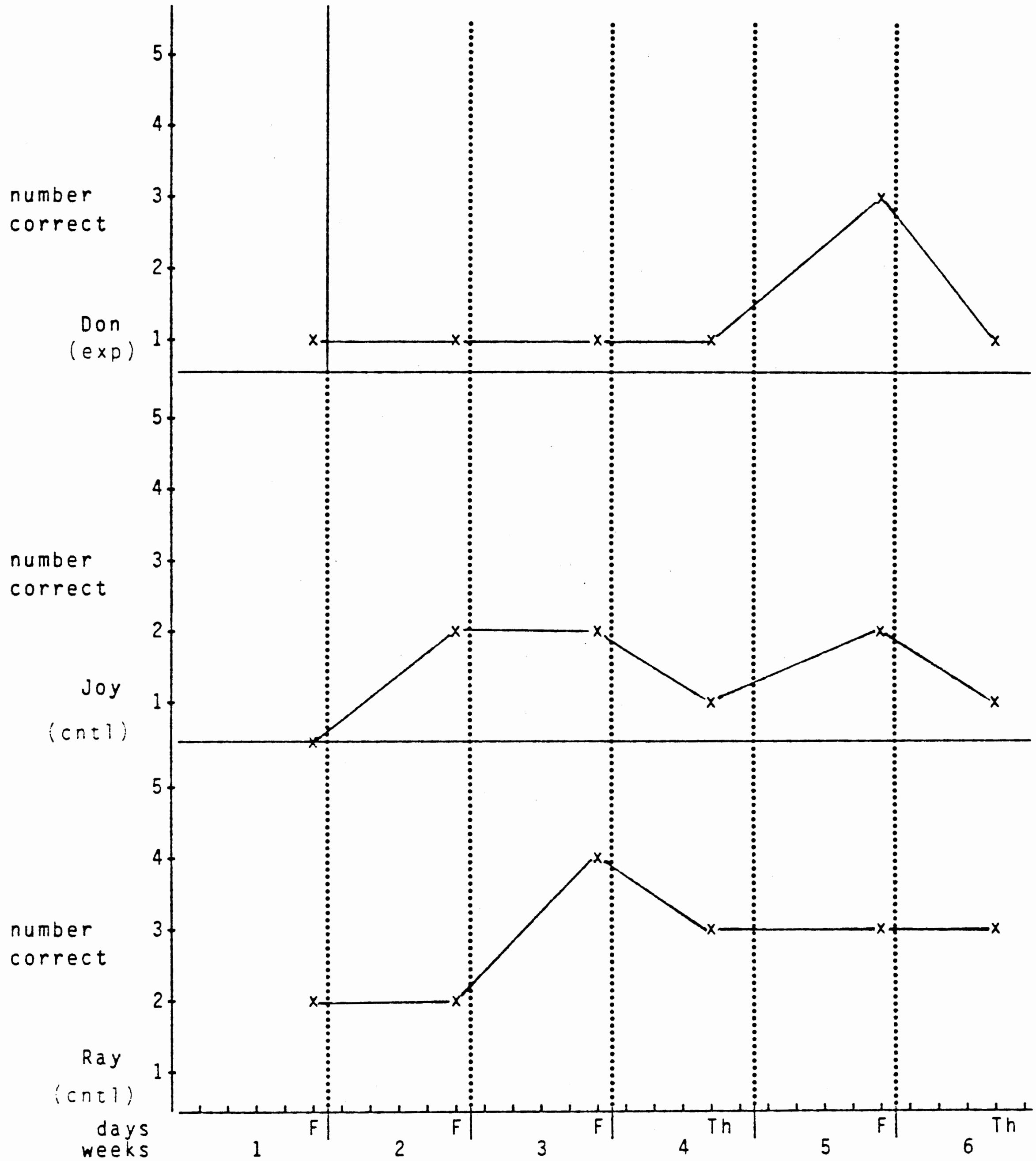


Figure 15.2. Number of correct responses on the classroom word problems: Don, Joy, and Ray. The difficulty level was increased the fourth week.

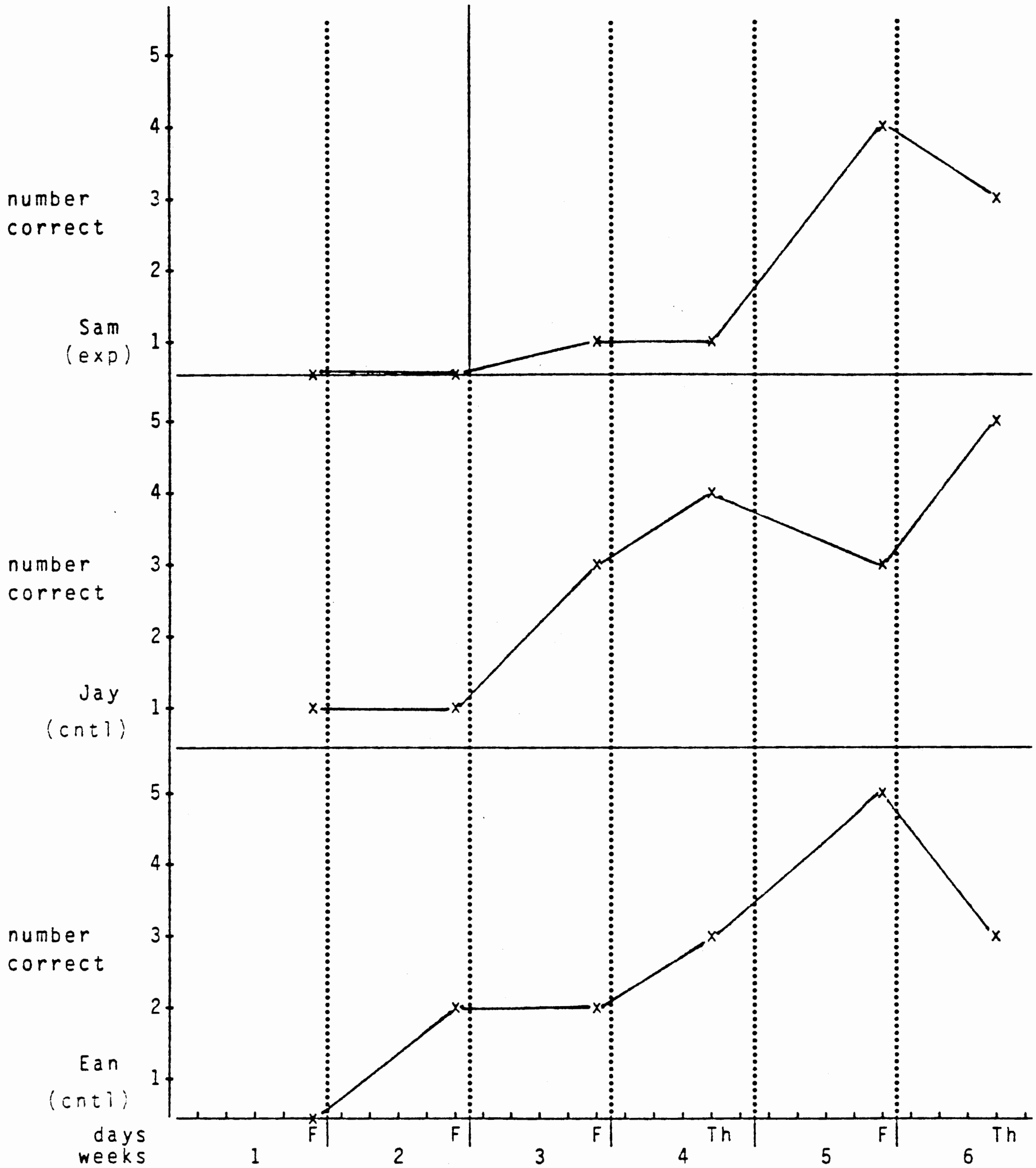


Figure 15.3. Number of correct responses on the classroom word problems: Sam, Jay, and Ean.

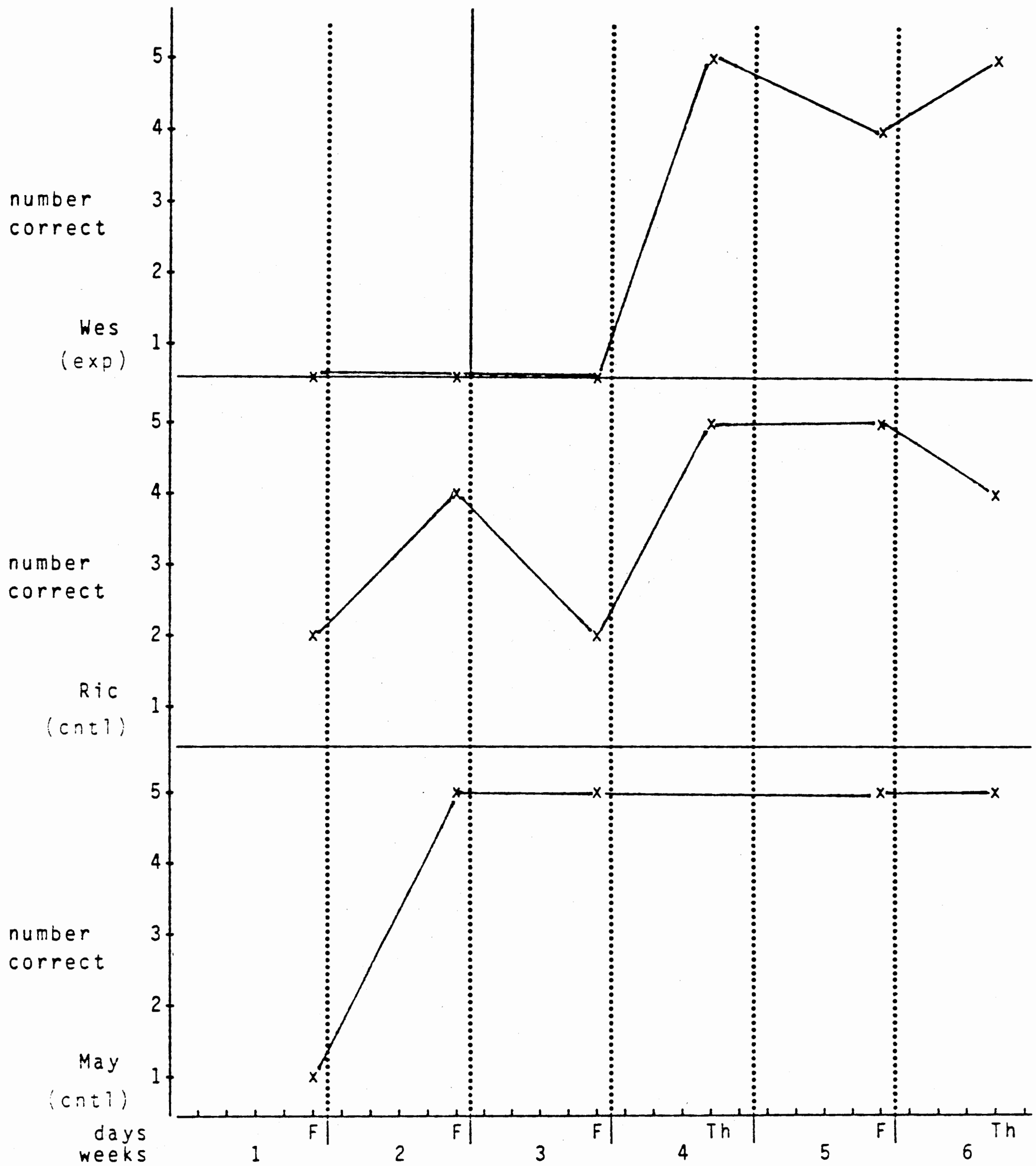


Figure 15.4. Number of correct responses on the classroom word problems: Wes, Ric, and May.

APPENDIX F

FOLLOW-UP DATA

TABLE VIII

PRE- AND POST-TEST STATISTICS FROM THE SELF-CONTROL RATING SCALE, ANALYZED BY DSM III DESCRIPTORS: TEACHER RATINGS

Inattention

DSM III Descriptor	# of scale items	Cal pre	Cal pst	Don pre	Don pst	Sam pre	Sam pst	Wes pre	Wes pst
		mean ratings							
a) Fails to finish things	(4)	6.8	5.8	2.8	3.8	5.8	5.3	5.3	5.0
b) Doesn't seem to listen	(2)	5.0	5.0	3.0	4.0	2.5	3.0	3.0	3.5
c) Easily distracted	(1)	6.0	5.0	5.0	5.0	6.0	5.0	7.0	5.0
d) Difficulty concentrating	(4)	6.3	5.3	5.3	4.8	5.5	4.8	5.3	5.0

Impulsivity

DSM III Descriptor	# of scale items	Cal pre	Cal pst	Don pre	Don pst	Sam pre	Sam pst	Wes pre	Wes pst
		mean ratings							
e) Acts before thinking	(1)	5.0	5.0	3.0	4.0	2.0	3.0	5.0	4.0
f) Shifts activities	(2)	5.5	4.5	5.0	4.0	5.5	5.0	5.5	5.0
g) Difficulty orgnzng. work	(2)	5.5	5.5	5.0	4.5	5.0	4.5	5.0	4.5
h) Needs supervision	(8)	4.6	4.1	2.4	3.8	5.1	3.8	3.1	4.1
i) Difficulty waiting	(5)	3.6	3.8	5.2	4.6	3.2	3.2	2.4	2.6

Except for DSM III descriptors c) and e), figures are based on mean ratings from more than one item on the Self-Control Rating Scale. The number of items used in determining the mean is indicated in parentheses to the right of each descriptor.

TABLE IX

PRE- AND POST-TEST DATA FROM THE SELF-CONTROL RATING SCALE, ANALYZED BY DSM III DESCRIPTORS: PARENT RATINGS

Inattention

DSM III Descriptor	# of scale items	Cal pre	Cal pst	Don pre	Don pst	Sam pre	Sam pst	Wes pre	Wes pst
		mean ratings							
a) Fails to finish things	(4)	5.0	4.8	5.3	5.0	5.8	5.3	6.8	5.8
b) Doesn't seem to listen	(2)	5.0	5.5	4.0	4.0	3.0	3.5	4.0	4.5
c) Easily distracted	(1)	5.0	4.0	5.0	5.0	7.0	7.0	7.0	5.0
d) Difficulty concentrating	(4)	5.3	5.0	5.0	4.8	6.3	5.0	6.0	5.5

Impulsivity

DSM III Descriptor	# of scale items	Cal pre	Cal pst	Don pre	Don pst	Sam pre	Sam pst	Wes pre	Wes pst
		mean ratings							
e) Acts before thinking	(1)	5.0	5.0	4.0	4.0	3.0	3.0	4.0	4.0
f) Shifts activities	(2)	5.0	4.5	5.5	4.5	4.5	4.0	4.0	4.0
g) Difficulty orgnzng. work	(2)	6.5	6.0	5.0	4.5	5.5	4.5	5.0	4.5
h) Needs supervision	(8)	4.0	4.1	4.0	4.0	3.4	3.5	2.5	2.9
i) Difficulty waiting	(5)	4.2	4.4	4.6	4.0	3.6	3.8	2.8	2.8

Except for DSM III descriptors c) and e), figures are based on mean ratings from more than one item on the Self-Control Rating Scale. The number of items used in determining the mean is indicated in parentheses to the right of each descriptor.

TABLE X

PRE- AND POST-TEST GRADE EQUIVALENCY SCORES FOR THE KeyMath OPERATIONS AND WORD PROBLEMS SUBTESTS

Operations: Written computations

	Addition		Subtraction		Multiplication		Division	
	pre	post	pre	post	pre	post	pre	post
Cal	2.9	4.0	3.2	3.9	3.9	4.5	1.1	1.1
Wes	5.5	5.5	6.6	7.8	5.3	6.1	2.4	4.2
Don	2.5	4.0	2.1	3.9	2.0	2.0	0.5	0.5
Sam	4.7	5.5	5.6	6.6	5.3	6.1	5.0	5.0

Operations: Mental computations and numerical reasoning. Word Problems.

	Mental Computations		Numerical Reasoning		Word Problems	
	pre	post	pre	post	pre	post
Cal	2.9	2.9	2.7	2.7	1.9	2.4
Wes	3.5	4.0	2.7	3.9	3.2	6.8
Don	2.9	3.5	2.2	2.2	3.7	4.2
Sam	3.5	4.5	3.3	3.9	3.2	5.3

Figures are grade equivalences. The lowest possible score is 0.5.

APPENDIX G

CONSENT AND RECORD FORMS

TEACHER
BEHAVIOR RATING SCALE

date:______________

teacher:____________________________ child:______________________________

(Please fill this out during the math progress check.
Base your answers on the entire math period.)

For what percentage of time was the child...

...on task?	10%	30%	50%	70%	90%
...preoccupied? (daydreaming, staring, fidgeting, talking to self)	10%	30%	50%	70%	90%
...disruptive? (out of seat, talking out of turn, bothering others)	10%	30%	50%	70%	90%

How many problems did the child do in a series without supervision?________

In the items below, the <u>4</u> shows where the average child would fall.

	1	2	3	4	5	6	7
1)Did the child settle down to work?	1 yes	2	3	<u>4</u>	5	6	7 no
2)Was the child easily distracted from work?	1 no	2	3	<u>4</u>	5	6	7 yes
3)Did the child jump from problem to problem or stick to one until finished?	1 sticks	2	3	<u>4</u>	5	6	7 jumps
4)Did the child think before answering?	1 yes	2	3	<u>4</u>	5	6	7 no
5)Did the child seem to be listening to you?	1 yes	2	3	<u>4</u>	5	6	7 no
6)Did the child have to be reminded several times to do something before doing it?	1 no	2	3	<u>4</u>	5	6	7 yes
7)Did the child work quickly?	1 quickly	2	3	<u>4</u>	5	6	7 slowly
8)Did the child master new concepts or fail to grasp them?	1 mastered	2	3	<u>4</u>	5	6	7 failed to grasp
9)Did the child first seek help with difficult problems, or get frustrated and quit?	1 seek help	2	3	<u>4</u>	5	6	7 quit

Comments:

685	535	589	855	585
+ 5	+ 7	+ 9	+ 9	+ 9
582	863	923	593	366
+ 8	+ 9	+ 7	+ 9	+ 5
738	769	663	193	729
+ 9	+ 1	+ 7	+ 2	+ 6
996	285	957	585	958
+ 8	+ 5	+ 6	+ 8	+ 3

654	164	424	142	817
- 6	- 9	- 9	- 5	- 8
483	218	111	741	141
- 3	- 8	- 6	- 7	- 1
653	165	322	125	125
- 6	- 6	- 6	- 9	- 7
352	731	461	335	621
- 7	- 6	- 3	- 7	- 4

54	24	77	26	64
x 5	x 9	x 8	x 6	x 6
86	94	69	22	59
x 8	x 9	x 2	x 7	x 2
37	69	67	85	53
x 8	x 8	x 5	x 9	x 7
63	65	85	37	82
x 2	x 2	x 9	x 9	x 8

45	95	46	36	65
x 47	x 56	x 57	x 93	x 68
34	99	28	68	66
x 78	x 92	x 82	x 47	x 88
54	97	45	78	73
x 49	x 54	x 68	x 36	x 23
73	28	53	88	54
x 46	x 93	x 59	x 48	x 38

ON TASK

OBSERVATION DATA SHEET

Observer:____________________ Date:________________

#	on	off	comment	#	on	off	comment
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			
8				8			
9				9			
10				10			
11				11			
12				12			
13				13			
14				14			
15				15			
16				16			
17				17			
18				18			
19				19			
20				20			
21				21			
22				22			
23				23			
24				24			
25				25			

Consent for child's participation in research

child's name ____________________________

I have been informed about the nature of the computer-assisted training program and about the procedures which will be used to research its effectiveness. I am aware that the project involves a short trip by car from South Murray Hall at Monroe and University to the summer school on McElroy, one and a half blocks west of Monroe. I agree to drop off my child at 7:45 am each day of summer school at South Murray Hall for the training and to pick him or her up at noon daily at the summer school building on McElroy.

I understand that my refusal to consent to my child's participation would not jeopardize his or her involvement in the regular summer school program. I have also been informed that I may withdraw my child from the computer-assisted training at any time without this affecting my child's treatment in the summer school program. If I want to know the results of the training project I will be informed after it is completed.

I believe my child is aware of the procedures to be used in the research project and does not feel forced to participate.

signature ____________________________

date ____________________________

TRAINING RECORD

Child: ____________ Trainer: ______________

Date: ______________ Initial segment: lab quiz ___
star book ___
cognitive training ___
computer math game ___

I. LAB QUIZ

problem type: A S M D level: ____

\# correct: ____ # attempted: ____ % correct: ____

II. STAR BOOK

problem type: A S M D level: ____

\# correct: ____ # attempted: ____ % correct: ____

accuracy criterion: ______ % correct. Star?: Y N

productivity criterion: ______ # correct. Star?: Y N

III. COGNITIVE TRAINING

problem type: A S M D level: 1 2 3

phase: echo cue flash aloud whisper covert

\# of problems: ____

\# of errors: ____

comment:

IV. COMPUTER MATH GAME

starting level: ____

current level: ____

\# correct: ____ # attempted: ____ % correct: ____

criterion met (score = 80%): Y N Reinforcer: __________

VITA 2

Steven Arthur Morton

Candidate for the degree of

Doctor of Philosophy

Thesis: GENERALIZATION OF COMPUTER-ASSISTED ATTENTION TRAINING FOR CHILDREN WITH ATTENTION DEFICIT DISORDER

Major Field: Psychology

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, October 11, 1951, the son of Robert Alva Morton, Sr. and Grace Ward Morton. Married to Kathi L. Miller on November 27, 1985.

Education: Graduated from Putnam City High School, Oklahoma City, Oklahoma, in May, 1969; received Bachelor of Arts degree in Psychology from Yale University in June, 1973; received Master of Arts degree in Clinical Psychology from Duquesne University in August, 1977; received Master of Science degree in Clinical Psychology from Oklahoma State University in December, 1985; completed requirements for the Doctor of Philosophy Degree at Oklahoma State University in July, 1988.

Professional Experience: Research Associate, Department of Psychology, Yale University, September, 1971, to July, 1973; Teaching Assistant, Department of Psychology, Duquesne University, August, 1977, to June, 1978; Counselor, Southwest Pennsylvania Youth Alternatives, October, 1977, to November, 1978; Therapist, South Hills Day Program, November, 1978, to August, 1980; Treatment Coordinator, St. John Medical Center, August, 1980, to August, 1982; Instructor, Department of Psychology, University of Steubenville, January, 1982, to June, 1982; Teaching Assistant, Oklahoma State University, August, 1982, to December, 1982; Treatment Coordinator, Shadow Mountain Institute, January, 1984, to August, 1985; Therapist, Stillwater Community Mental Health, August, 1985, to August, 1986; District Coordinator of District XI Task Force on Child Abuse Prevention, August, 1986, to August, 1987.

Member: Board of Directors, Oklahoma Committee for the Prevention of Child Abuse; Oklahoma Permanency Planning Task Force; Oklahoma Coalition for Children, Youth, and Families.