The Effects of Methylphenidate on the Learning and Performance of a Child Diagnosed ADDH

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THE EFFECTS OF METHYLPHENIDATE ON THE LEARNING AND PERFORMANCE OF A CHILD DIAGNOSED ADDH

by

Kendra Leigh Heath

A Thesis Submitted to the Faculty of The Graduate College in partial fulfillment of the requirements for the Degree of Master of Arts Department of Psychology

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THE EFFECTS OF METHYLPHENIDATE ON THE LEARNING AND PERFORMANCE OF A CHILD DIAGNOSED ADDH

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Western Michigan University, 1986

The effects of methylphenidate (Ritalin) on the learning and performance of a child diagnosed Attention Deficit Disorder with Hyperactivity (ADDH) was evaluated using a repeated acquisition apparatus. A placebo and three dosages of methylphenidate were evaluated in both the learning and performance components of the experiment. Dosages tested included the subject's therapeutic dosage, a dosage 5 mg higher, and a dosage 5 mg lower. Methylphenidate produced no effect of consequence on the number of errors per session, suggesting that the medication neither impaired nor facilitated learning or performance at the range of dosages investigated. Data were also collected on social behavior in the classroom with the Connor's Abbreviated Teacher's Rating Scale (CATRS). No score fell within the hyperactive range of the scale during the experiment and there was no consistent dose-dependent effects demonstrated.
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CHAPTER I

INTRODUCTION

The Problem

Attention Deficit Disorder with Hyperactivity (ADDH) is characterized by extreme inattentiveness, impulsivity, distractibility, and overactivity (American Psychiatric Association, 1980). Other possible indicators that are seen frequently include academic failure, conduct disorders, lack of motor coordination, and poor peer relationships (Schworm, 1982). Still referred to as hyperkinesis, hyperactivity, learning disability, or minimal brain dysfunction by many professionals, the incidence estimates of ADDH vary widely, ranging from 3% to 20% of all children (Taylor, 1980). Originating in 1937 when Bradley first documented the use of stimulants as a treatment for childhood behavior disorders, stimulant medication is now routinely prescribed for the treatment of ADDH (Gan & Cantwell, 1982). In addition, O'Leary (1980) stated that the use of stimulants in this manner has increased significantly in the past 20 years. Gadow (1981) reported that approximately 1% to 2% of all elementary school aged children in 1981 were receiving stimulant medication for hyperactivity.
Effects of Methylphenidate Treatment

Methylphenidate hydrochloride, or Ritalin, appears to be the preferred drug in both actual clinical use (Gadow, 1981; O'Leary, 1980) and research studies (Barkley & Cunningham, 1978). As such, there exists a plethora of evidence illustrating that methylphenidate successfully reduces overactivity and impulsivity (Abikoff & Gittelman, 1985; Brown & Sleator, 1979; Brown, Slimmer, & Wynne, 1984; Sprague & Sleator, 1977) and increases attentional behavior and concentration (Abikoff & Gittelman, 1985; Brown et al., 1984; Sykes, Douglas, Weiss, & Minde, 1971; Thurston, Solbol, Swanson, & Kinsbourne, 1979). Unfortunately, in studies attempting to determine if methylphenidate treatment improves academic performance and learning the results point in the opposite direction. In a review conducted by Barkley and Cunningham (1978), they found that out of 12 short-term studies which examined the impact of methylphenidate on various academic measures only 3 showed significant improvements, and these improvements did not occur on every measure used in each study. Furthermore, the authors of 2 of the 3 studies attributed their positive results to an increase in attention, not improved achievement skills (H. E. Rie, Rie, Stewart, & Ambuel, 1976a, 1976b).

Realistically, it is not surprising to find no improvements in academic performance during studies that ranged from 2 weeks to 6 months in length as the measures generally used (standardized tests) were not sensitive enough to detect changes occurring over such a short time period (Barkley & Cunningham, 1978; O'Leary, 1980).
However, long-term research studies also fail to demonstrate academic improvement as a result of stimulant treatment. For example, Charles and Schain (1981) evaluated 62 children 4 years after they had been diagnosed and treated as hyperactive. Results from their study determined that most of the participants (77%) were functioning 2 or more years below the normal level for their respective age groups on one or more of the Wide Range Achievement Test (WRAT) and Peabody Individual Achievement Test (PIAT) subtests. Teachers' reports indicated that 74% were achieving below their grade level in reading, 69% in math, and 66% were unable to maintain adequate attention. Also, 34% had repeated one or more grades, 42% were in special classes, and 24% were being tutored. Only 35% were attending regular classes that were age appropriate and receiving no support services. However, the lack of a control group for comparison of academic achievement and placement with the study's participants in addition to the exclusion of information on the subjects' academic achievement prior to drug treatment should be considered when the results are interpreted.

Generally, extensive literature reviews and other long-term studies support the findings of Charles and Schain (1981) (Barkley & Cunningham, 1978; O'Leary, 1980; E. D. Rie & Rie, 1977).

The discrepancy that exists between the effect of methylphenidate on hyperactive behaviors (inattentiveness, impulsiveness, and constant motion) and its effect on academic performance has fostered many plausible explanations for its occurrence. By far the most widely held explanation is that different doses have varying effects on different target behaviors (Brown & Sleator, 1979;
Sleator & Sprague, 1974; Sprague & Sleator, 1977; Walker, 1982). These studies have shown that the dose which results in the maximum improvement in social behavior (1.0 mg/kg) impairs academic performance (which is optimally enhanced at 0.3 mg/kg). Barkley and Cunningham (1978) provided a novel explanation by suggesting that the child's age at treatment onset may play a significant role in the documented discrepancy. They propose that an older child with a history of academic difficulties may experience little or no drug-induced academic improvement as the child has probably failed to learn the basic skills necessary for mastery of more complex material. Before any explanation can be widely adopted, it is clear that further empirical evidence is needed in this area.
CHAPTER II

REVIEW OF SELECTED LITERATURE

Most studies of the effects of stimulant medication on academic performance have looked at academic measures involving only the recall and application of previously acquired material (Gadow, 1981, Walker, 1982). Another area requiring additional investigation concerns the effects of stimulants on the rate and ease of acquisition of new material. Considering the widespread use of stimulants with school aged children and the potential educational implications of impairments in learning, it is amazing that more research has not been conducted to assess the effects of methylphenidate on knowledge acquisition. Of the studies that have evaluated this hypothesis, two have reported that the stimulants tested had no affect on learning as measured by paired associate learning tasks (Aman & Sprague, 1974; Connors, 1966). Three other studies using paired associate learning tasks similar to the previously mentioned studies produced contradictory results with 45% to 70% of the subjects experiencing enhanced learning while the other subjects experienced impaired learning or no learning change (Swanson & Kinsbourne, 1976; Swanson, Kinsbourne, Roberts, & Zucker, 1978; Swanson, Sandman, Deutsch, & Baren, 1983). Among the factors that could account for contradictory results are: subtle differences in the task used to assess acquisition and differences in dosages administered to the subjects. Unfortunately,
standardized dosages (mg/kg) used in these studies were not reported. Whatever the explanation for these conflicting results, their occurrence provides one more reason for further investigation in this area.

Several significant methodological problems surface when planning a study on learning. First, the tasks used in within-subject experimental designs must possess the same degree of difficulty across repeated measures (Yoder & Fuqua, 1984). In addition, problems with individual subject differences and dependence upon statistical analyses also arise, as do other problems generally encountered in group designs (Hersen & Barlow, 1976; Sidman, 1960). Many of these problems appear to be eliminated when a within-subject experimental design is combined with a repeated acquisition procedure first described by Boren in 1963 (Thompson, 1973). Since 1963, many studies have evaluated the effects of various drugs on learning using this procedure (Handley & Calhoun, 1978; Thompson, 1973, 1976; Walker, 1982; Yoder & Fuqua, 1984).

Thompson (1976) used the repeated acquisition procedure to assess the effects of methylphenidate and imipramine (Tofranil) on learning and performance in three pigeons. The pigeons' task was to peck the correct key when the three response keys were illuminated with a given color so as to successfully complete a 4-response chain and receive reinforcement. When an incorrect response occurred, a 5-second time-out followed. After stable error rates were reached, the drugs were administered and their effects on learning and performance recorded. From the obtained results the author concluded
that methylphenidate impaired learning at each dose tested (2.5, 5, 10, and 20 mg/kg) whereas performance was unaffected at all doses except the highest. This adds further evidence for the hypothesis that different dose-response relations exist for different target behaviors (i.e., acquisition vs. performance) with respect to methylphenidate.

Walker (1982) extended Thompson's (1976) work by using the repeated acquisition task to assess the effects of methylphenidate on learning in hyperactive children. The subjects were instructed to learn three different six-component behavioral chains associated with three discriminative stimuli. When the subject completed five chains (FR-5), a point was delivered and appeared on the computer screen being used by the subject. When an error occurred, a time-out was enacted and the screen went blank for 2 seconds after which the subject was returned to the same link in the chain. Walker (1982) looked at the effects of 0.3 and 0.7 mg/kg of methylphenidate and a placebo condition on the rate of learning (number of errors and response rate). Through statistical analyses of the data, the author concluded that both doses enhanced learning (decreased error rate and increased response rate) significantly with the highest dose having the greatest effect.

Walker's (1982) results are in contrast to Thompson's (1976) study which concluded that all doses of methylphenidate impaired learning. Possible explanations for this include species and methodological differences (Walker, 1982; Yoder & Fuqua, 1984). These results also conflict with Sprague and Sleator's (1977) conclusion
that 0.3 mg/kg produces the optimal improvement in short-term memory. This conflict may be explained in terms of different dose-response curves for learning and memory when methylphenidate is used, or since 0.7 mg/kg is between the doses tested by Sprague and Sleator (1977) (0.3 and 1.0 mg/kg), the results actually may not be in conflict at all (Yoder & Fuqua, 1984).

In the most recent study to assess the effects of methylphenidate on learning and performance, Yoder and Fuqua (1984) evaluated four hyperactive children with a repeated acquisition task that included learning and performance components. In addition, hyperactivity was also assessed with the Connor's Abbreviated Teachers Rating Scale (CATRS) weekly and classroom academic measures were monitored for two of the subjects. Three methylphenidate dosages (subject's current therapeutic dose, 5 mg/kg higher, and 5 mg/kg lower) and one placebo condition were evaluated during this study. The repeated acquisition task required the subject to complete a six-component chain by choosing the appropriate chip from each of six groups of three. A 5-second time-out was enacted for each selection error during which the display board was covered. The subject was returned to the same link in the chain after the time-out had expired. Reinforcement occurred upon completion of a response sequence. Points earned in this manner could be exchanged for dimes or video game tokens at the end of the sessions. Learning and performance components were conducted during each session with the learning task occurring first. A new response chain was created for each session in the learning component, whereas the task remained the
same for the performance component throughout the experiment. The authors concluded that methylphenidate neither impairs nor enhances learning and performance. The academic measures monitored for two of the subjects improved under placebo conditions and CATRS scores generally decreased as the dosage increased. This supports the theory that different target behaviors have varying dose-response relations (Brown & Sleator, 1979; Sleator & Sprague, 1974; Sprague & Sleator, 1977; Walker, 1982). Also, the data from this study are in conflict with Thompson's (1976) conclusion that methylphenidate impairs learning and Walker's (1982) results indicating enhancement of learning with methylphenidate. Many explanations may be offered for this occurrence including species and methodological differences in the former and subject and methodological differences in the latter. In addition, the results of the Yoder and Fuqua (1984) study should be interpreted cautiously because of the high degree of variability seen throughout the data and the low error rates and high response rates generated by the repeated acquisition task prior to contact with the independent variable. The detection of a drug effect on learning as reflected in a reduction in errors may have been prevented because of the low error rates that occurred in the study.

When the popularity of methylphenidate as a treatment for hyperactivity in school-aged children is considered along with the conflicting results obtained from learning studies so far, it is clear that this is an area requiring further assessment. This study extended Yoder and Fuqua's (1984) study by using a more difficult
repeated acquisition task. Dependent variables included error rates on the learning and performance components of the repeated acquisition task and hyperactivity ratings obtained from the CATRS with the intent to determine the effects methylphenidate has on learning and performance in a child with ADDH.
CHAPTER III

METHODOLOGY

Subject Selection and Setting

Several community based pediatricians were contacted by mail and phone and asked for their help in the recruitment of subjects. They were informed of the study's intent and format and provided with criteria that the potential subjects needed to meet prior to inclusion. These criteria included: (a) a diagnosis of ADDH, (b) ages 6-12, and (c) have been taking Ritalin for a minimum of 3 months. The physicians sent letters to over 25 potential participants and contacted many others in person; however, only two interested parents contacted the experimenter. Both of the potential subjects fulfilled the criteria listed earlier and were selected to participate. Unfortunately, one of the children developed a significant health problem and was withdrawn 3 days prior to the start of the experiment.

The purposes of the study were explained to the subject's mother, the procedure was demonstrated, and informed consent was obtained prior to the start of the study (Appendix A). In addition, the procedure was explained to the subject, Patrick, who then agreed to participate willingly. Patrick was 7 years old and attended a normal first grade class at the time of the experiment. He had a history of attentional and behavioral problems in school and had been
on Ritalin for at least one year.

The procedure was conducted in a room at the subject's school which contained two tables, a blackboard, and 10 chairs. The other data were obtained by the teacher in the classroom setting.

Apparatus and Other Materials

The repeated acquisition apparatus was made of two pieces of 1/8 inch thick hardboard 22 inches long and 18 inches wide. The top piece had seven rows of six round holes each cut into it and was secured to the second piece of hardboard with glue. The diameter of the holes was 1 3/4 inches, sufficiently large to enable a poker chip to fit loosely into them and be taken out easily. Rows of chips were separated by 1 1/2 inches and chips within each row were 1 inch apart. There were copper rivets secured 1 inch from the edge (on the left and right sides of the apparatus) between the rows, above the first row and below the sixth row. This enabled an 18 1/4 inch by 2 3/4 inch piece of hardboard to be slid across each of the first six rows to prevent the subject from viewing the rows not currently being worked on. It also functioned as a discriminative stimulus and was used to indicate which of the six rows was the appropriate one in which to make a response. The first six rows contained six white poker chips, with each chip possessing a 1/2 inch by 3/4 inch colored sticker on the bottom side in one of six colors (purple, green, yellow, blue, orange, and red). The seventh row remained empty until the procedure was in process.
Poker chips and a jar were used by the experimenter during the sessions to provide immediate reinforcement to the subject upon completion of a sequence. Back-up reinforcers were decided upon prior to the start of the experiment by a joint decision between the experimenter, the subject, and the subject's mother. The subject exchanged the poker chips earned in the day's session for video game tokens. A card was written out each day informing the mother how many chips were earned, how many video game tokens should be received, and how many chips were carried over to the next testing day. In general, the tokens were delivered reliably; however, occasionally Patrick reported that his mother "owed" him a specific number of tokens but he consistently reported receiving these tokens within 2 days of the sessions in which they were earned.

Data Collection and Reliability

Data were collected on the number of errors during both the learning and performance components. Errors were defined as an incorrect choice of a chip, choosing a chip from an unexposed row, and no response at all by the subject within 5 seconds after a row had been exposed. The position of the errors was also recorded so as to detect any position preferences.

The experimenter used data sheets (Appendix B) on which was recorded when and where each error occurred, the total number of responses, the number of incorrect and correct responses, and the elapsed time for the specific component. These data were collected during every session, for the entire session.
The reliability observer, a professional with an advanced degree in human services, was trained on the recording procedure prior to encountering the actual subject in the experimental setting. The observer practiced scoring the procedure during several demonstrations until it could be done quickly and accurately, without any errors committed.

Interobserver agreement checks were conducted in a nonblind fashion on every fourth day throughout the entire experiment for a total of eight sessions (23% of the total number of sessions). The observer sat behind and to the right of the subject with a clear view of the subject and repeated acquisition apparatus. The observer recorded the subject's behavior in the same manner as the experimenter. These records were compared after the session had terminated. Percentage agreement was determined by the following formula: agreements on the occurrence of an error by the subject/agreements + disagreements x 100. There was 100% agreement between the experimenter and observer on the occurrence of each error committed by the subject on a trial-by-trial basis.

Hyperactivity ratings were obtained from the Connor's Abbreviated Teacher's Rating Scale (CATRS) which was completed by the subject's teacher. These ratings occurred once each week on Friday and reflected the subject's morning behavior for the entire week. Academic measures were not available as no assignment was given to the subject on a daily or regular basis.
Procedure

For this study the independent variable was the subject's morning dose of methylphenidate. This was the therapeutic dose that the subject was prescribed and taking prior to the study. Other doses tested throughout the experiment included 5 mg higher than the baseline dose, 5 mg lower, and a placebo condition.

The stimulant medication was delivered to the parents every Friday in sealed and dated envelopes. Since placebos could not be located for the Ritalin, another method to prevent the subject and others involved from determining what dosage of medication was being given was utilized. Each envelope contained the appropriate dosage of methylphenidate ground to a powder in addition to a specific amount of a neutral substance, vitamin B-1. During the placebo phase the subject received only the ground up vitamin. Enough B-1 was combined with every dose of methylphenidate so that the powder in each envelope during each phase was approximately the same and the taste of the Ritalin could not be detected. The subject was administered the medication in a water solution on a spoon and followed it with a glass of water. Only the experimenter was aware of the dosage changes when they occurred; all others involved were only aware that dose changes, if they occurred, would occur over the weekend. The parents were responsible for insuring that the medication was administered each morning.

Because of the short biologically active life of methylphenidate, the sessions occurred 2 hours after ingestion of the drug.
(Oettinger & Majovski, 1976; Swanson et al., 1978). The sessions occurred at the same time each day and lasted no longer than 30 minutes (20 minutes for the learning component and 10 minutes for the performance component).

Throughout the study the subject was seated across from the experimenter and the apparatus was on the table between them. The seventh (empty) row was nearest to the subject. The jar and poker chips delivered upon completion of the response sequence were on the experimenter's left and the data sheets were attached to a clipboard and kept from the subject's view.

The subject was instructed to select the chip in each group of six (starting with the row closest to the experimenter) that he believed to be correct. If the selected chip was correct, the subject placed that chip into the position in the seventh row that corresponded to the row from which the chip was selected (e.g., the chip from the first row went in the first position of the seventh row, the chip from the second row went in the second position of the seventh row, etc.). Upon completion of the entire response sequence, the subject received a chip for its completion and two chips if it was completed without any errors. A short, simple statement of approval (e.g., "That's right," "You're correct," etc.) was voiced by the experimenter when the correct chip was chosen. When an error was made (wrong chip chosen, no chip chosen within 5 seconds after a row had been exposed, or chip chosen from an unexposed row) the experimenter said, "No, that's not right." The subject then replaced the chip in its original position and chose another chip. When a
sequence was completed, one or two chips (based on the accuracy of the subject's performance) were deposited in the jar, the chips were replaced in their original positions in view of the subject, and the sequence started over.

As mentioned earlier, each session included a learning and performance component which lasted 20 and 10 minutes, respectively, and consisted of 10 trials each. The learning component included a new response sequence every day and the performance component had the same sequence throughout the study. Upon completion of the learning component the experimenter placed the chips in the correct sequence in the apparatus for the performance component. Prior to the start of each component the subject was informed whether he was working on a novel sequence or the one that he knew.

The response sequences used in the study were determined during the preexperiment sessions and the ones chosen generated 10 or more errors per session for at least 5 sessions (to insure a difficult task). The sequences were randomly generated with the following restrictions: (a) a given position (1, 2, 3, 4, 5, or 6) could not be repeated consecutively within a chain; (b) for a given link of the six-link chain, the same position could not be designated as correct for more than two consecutive sessions; and (c) a given two-link sequence (i.e., 1 and 4) could not appear more than once within a single chain.

The preexperiment sessions lasted 10 days and instructions and reverse chaining were used to train the subject on the experimental task. The subject earned chips initially for turning over the last
chip in the sequence, then the last two chips, etc. until the entire sequence was completed. Criterion for mastery of the performance component was 100% correct sequence completion on 10 trials over 2 consecutive days. The experiment started when the performance component was mastered and the number of errors in the learning component was stable.

Experimental Design

The study consisted of five phases: (a) baseline (0.23 mg/kg), (b) higher (0.34 mg/kg), (c) lower (0.11 mg/kg), (d) placebo, and (e) baseline. The preexperiment training occurred prior to the initial baseline phase with the subject receiving the baseline dose of medication. Except for the initial training, the procedure during all phases was conducted in the same manner.

Each phase lasted at least 5 days with a change to the next phase being determined by visual inspection of the data, degree of variability, and the amount of the school year left.
CHAPTER IV

RESULTS

Figure 1 shows the number of errors per session for the subject in both the learning and performance components of the experiment.

![Graph showing number of errors per session for learning and performance components at all dosage levels tested.](image)

Figure 1. Number of Errors per Session for the Learning and Performance Components at All Dosage Levels Tested.
An extreme amount of variability was seen within and across all phases with only the data during the decreased dosage phase approaching stability. The first baseline phase showed the largest degree of variability with the range of errors being 19-102. No stable changes were seen in the number of errors or trends within phases when dosage changes occurred. At the start of each new phase there was a very evident initial change in the errors per session from the previous phase; however, these changes were not maintained throughout the entire phase. A slight upward shift of the data was evident in the placebo phase as compared to the other medication phases (excluding the initial baseline phase). No errors occurred during the performance component until the second baseline when one error occurred on two different occasions.

Figure 2 shows the mean errors per session at each dosage level tested for each of the experimental components. Errors during the learning component always exceeded those that occurred during the performance component at all dosage levels. The brackets represent one standard deviation and depict the high degree of variability in the error rate that was present within each phase. Relatively small differences between the data for each phase suggests the absence of a strong drug effect on learning. Again, when the initial baseline was disregarded and the other data viewed, the mean errors during the placebo phase slightly exceeded those in the other phases. When the data are rearranged by dosage, from the smallest to the largest, a U-shaped curve is formed as the placebo and highest doses have greater mean error rates than the baseline and lower doses (when the initial
baseline is not considered). This curve is similar to that obtained on the dose-response effects of methylphenidate on short-term memory (Sprague & Sleator, 1977), on problems completed (Rapport, Murphy, & Bailey, 1982), and on learning (Yoder & Fuqua, 1984).

Figure 2. Mean Number of Errors per Session in Both Learning and Performance Components at Each Given Dosage.

Figure 3 shows the mean errors per trial, a measure of within session learning, for each phase. The majority of errors occurred on the first trial when guessing was required. After than, the errors decreased rapidly and approached zero by the fourth trial in three of
the phases. Errors in the first baseline phase never went below one and errors during the placebo phase were much more variable and did not approach zero until the seventh trial.

Figure 3. Mean Number of Errors per Trial in the Learning and Performance Components at Each Given Dosage.

The classroom measures of hyperactivity provided by the subject's teacher are displayed in Figure 4. Patrick never received a score on the CATRS that fell in the hyperactive range of the scale. The highest score occurred during the initial baseline phase and the lowest score occurred during the second baseline phase. It should be
noted that both the initial baseline and placebo scores are the product of one weekly score, whereas the other three scores are the means of two weekly scores.

![Graph showing mean scores on the CATRS at each dosage level](image).

**Figure 4.** Mean Scores on the CATRS at Each Dosage Level.
CHAPTER V

DISCUSSION

The results of this study suggest that methylphenidate, at the dosages tested, neither impairs nor facilitates learning in children diagnosed ADDH. Of course, this conclusion should be interpreted cautiously because of the high degree of variability that was present, the single subject design, and the limited range of doses tested. However, these results are in agreement with the conclusions of the Yoder and Fuqua (1984) study that looked at the effects of methylphenidate on learning and performance in four subjects. As with the Yoder and Fuqua (1984) study, this experiment's results are in contrast with the results obtained in Walker's (1982) study with humans and Thompson's (1976) study with pigeons. The author of the first study concluded that both doses tested (0.3 and 0.7 mg/kg) enhanced learning significantly with the highest dose having the greatest effect. The latter study investigated a wider range of doses (1.5, 5, 10, and 20 mg/kg) and concluded that methylphenidate impaired learning of pigeons at each dose tested, whereas performance was unaffected at all doses except the highest. There are several explanations available for the contradictory results. These include species differences in the case of the current study compared to Thompson's (1976) study, as well as the widely differing dosages of methylphenidate tested. Also, Walker's (1982) initial data were
barely significant so a statistical analysis was performed to transform the data and make the results appear more significant. There were also many methodological differences between the three studies.

Even though a high level of variability was present throughout the data, the occurrence of a slight, inconsequential drug effect may be argued. This is suggested in Figure 3 as the placebo phase curve is more variable and approaches zero at a trial beyond which three of the other four phases have approached it. Figure 1 also suggests the same effect as the data in the placebo condition are shifted slightly upward as compared to the other phases (excluding the initial baseline phase). In addition, this slight effect may be demonstrated in the second figure as the mean errors per session is the highest during the placebo condition. However, given the high level of variability in the data, the small number of data days comprising the placebo condition, the overlapping of data points between the placebo phase and the other phases, and the subject's inconsistent performance in the baseline phases, the conclusion that a small drug effect exists should be drawn with extreme caution.

As mentioned earlier, the U-shaped curve evident in Figure 2 when the data are rearranged (PL, 0.11, 0.23, 0.34) is similar to short-term memory curves obtained by Sprague and Sleator (1977), dose-response effects of methylphenidate on learning obtained by Yoder and Fuqua (1984), and problems completed curve obtained by Rapport et al. (1982). This conclusion should be made with extreme caution as the dosages tested in this study fell at the lower range of dosages tested in the previously mentioned studies. In the
current study, the mean errors per session during the low dosage condition is less than the mean errors present in the placebo and the high dosage condition. Compilation of these data imply that there is an optimal dose of methylphenidate for learning measures and that varying from this dose would have an undesirable effect on the learning measure. It can be extrapolated further that there is a necessity for physicians to investigate the effects of several dosages of methylphenidate on social and cognitive measures with each child prior to prescribing a maintenance dose of the medication as the optimal dosage of the medication may vary for different target behaviors.

Variability was most obvious during the initial baseline phase despite the rigorous attempts to ensure a stable testing situation. It is unknown exactly what caused the high degree of variability but a few possibilities exist. This phase occurred right after the subject's spring break and the variable data may have been due, in part, to the subject's difficulty in settling down after being off from school for a week. Patrick also cried very often during this phase for no reason apparent to the experimenter. The experimenter discussed the situation with Patrick's teacher and mother. Both agreed that Patrick had been more emotional and unpredictable than usual but no specific reason could be identified. This is also the condition in which Patrick received the highest hyperactivity score on the CATRS. Ideally, this phase should have been extended until the data were less variable. Unfortunately, the teacher's and mother's concern regarding Patrick's behavior and the remaining
school year were determinants of the phase change occurring when it did.

The CATRS, completed weekly by the teacher, is a measure of questionable reliability and validity as it involves a subjective rating scale. In this study the measure did not appear sufficiently sensitive to adequately represent Patrick's morning behavior. Even though Patrick received the highest scores in the first baseline and placebo conditions, both scores fall well below the hyperactive level on the scale (15). During the placebo phase the subject was very difficult to keep on task and was frequently moving about the room or playing with the chairs. The teacher also commented at this time that he spoke out of turn often and was uncooperative. What occurred during the testing sessions indicated a much higher score on the CATRS than what was received. With this under consideration, the sensitivity and validity of the CATRS is in question, as well as the reliability of the teacher's ratings and her sensitivity to the child's morning behavior. It can also be questioned whether the child is hyperactive; however, a diagnosis of ADDH by a pediatrician, subjective observations made by the experimenter during the study, and reports from the mother indicate otherwise.

In terms of variability and highest error rates, the placebo and first baseline conditions far surpassed the other three conditions. It should be noted that these conditions only lasted 5 days each compared to the other conditions which lasted 7 to 9 days. The possibility exists that more data during these conditions may have reduced the variability so much more evident in these two phases as
well as affected the CATRS scores obtained during these phases also.

There are several areas in which this research could be improved upon in the future. First, all the phases should be extended until the data are less variable. This would allow any drug effects to be seen more clearly and conclusions could be drawn with more confidence. Second, academic measures that occur on a daily basis and are of a standard difficulty and representative of other academic tasks should be included as an indicator of the effects methylphenidate has on actual classroom measures of learning. These measures were not available for this study as no academic measure occurred in the morning on a daily basis for the subject. Also, these measures should be correlated with the repeated acquisition procedure to determine if the procedure is comparable enough to enable it to be used as a valid indicator of the effects various medications have on learning measures used in the classroom. In addition, research investigating the effects of a wide range of dosages on various target behaviors is needed to further assess dose-response relations. Lastly, the tokens used in the experiment should be gradually faded out at the end of the experiment in order to determine if they were maintaining the subject's responding. Since tokens are not frequently used in a classroom setting, this is an important area for investigation.

The findings of the present study concur with those of Yoder and Fuqua (1984) that methylphenidate neither impairs nor facilitates learning and performance as measured by the repeated acquisition task in children diagnosed ADDH. Considering the contrasting findings
existing in this area, it is clear that there is more research to be
done on the effects of Ritalin.
Appendix A

Informed Consent Form
Informed Consent Form

We, _________________________________________________, the parents of _________________________________________________, authorize the experimenter to include our child in a study of the effects of methylphenidate on learning and performance. A repeated acquisition procedure will be used in the study which will require the child to complete a response sequence consisting of six components. The dose of methylphenidate currently being taken by the child will be altered occasionally during the study (increased by 5 mg/kg, decreased by 5 mg/kg, and replaced by a placebo). These changes should not last more than 2 weeks each. We agree to continue giving the medication as prescribed throughout the study and will inform the experimenter prior to any necessary changes.

This study is understood to provide minimal risk to the child as the apparatus to be used will be similar to a store bought game board, the planned dosage changes have not been reported to produce any adverse reactions, and the child will not be taken out of his/her classroom during programmed instruction. Benefits to the child may result from the one-on-one interactions with an adult each day during the study. These may include an increased sense of self-importance and self-esteem because of inclusion in the study and added attention.

We also understand that we have the right to question the experimenter concerning the study and the child's role in it and that we can remove our child at any time from the study. Furthermore, any information obtained from the study will be confidential. By signing
this form we understand that the data may be used in scientific presentations and publications and that all identifying information will be removed so that the child's identity will remain confidential.

Your signatures below indicate that you have read and understood the above information and decided to allow your child to participate in the study. You will be given a copy of this form to keep.

Signed

Witnessed

Signed

Dated
Appendix B

Recording Form
## Recording Form

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**Trial ___**

1. Total # responses ______ (incorrect & correct)
2. Total # of errors ______
3. Component time ______ min. (end - start)

**Trial ___**

**Trial ___**
## Recording Form (page 2)

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**Correct sequence**
BIBLIOGRAPHY


